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THE TEACHING OF FORESTRY.

A Manual of Forestry. By William Schlich, Ph.D. Vol. I. (London: Bradbury, Agnew, and Co., 1889.)

PROBABLY it will not for some time be generally recognized in England that forestry is a profession in the sense in which we speak of the profession of law or of medicine. And it is a bold step to publish a manual of forestry for English readers in a systematic and strictly technical form. This is the task which Dr. Schlich has undertaken, and the volume before us is the first instalment of a large work, which, when completed, will be the first comprehensive manual of forestry in the English language.

Before going out to India in 1866, Dr. Schlich had passed the examinations for the superior forest service in his own country (Hesse Darmstadt), he had been the pupil of one of the most eminent Professors of Forestry in Germany, the late Gustav Heyer, and he held a distinguished place among his fellow students. At the commencement of his career, the changes which had taken place in Hesse Darmstadt in consequence of the Austrian war were believed to affect injuriously the chances of promotion for the younger members of the forest service. This induced him to accept the offer of an appointment in India. Here he was designated at an early date for important positions, and thus, after he had served several years in Burmah, he was sent to Sind, where, under completely different conditions of climate and forest, he did excellent work. He served successively as Conservator of Forests in Lower Bengal and in the Punjab, until he rose to the post of Inspector-General of Forests. In 1885 he consented to relinquish his important position in India, in order to become Professor of Forestry at the Forest School which it had been decided to form in connection with the Royal Indian Engineering College at Coopers Hill.

The volume before us contains the general and introductory part; in a second volume the author proposes to set forth in detail the different sylvicultural operations; while the protection of forests, the utilization of timber and other forest produce, the systematic arrangement of the plans for working, and the financial aspect of forest management, will complete the work. Not the least of the advantages which will be gained by the publication of this manual will be to settle the English forest terminology. The technical terms which had been tentatively used since methodical forest management was begun in India may now be expected to receive general currency, and will be more correctly understood than before.

The primary object of the Coopers Hill Forest School is the training of officers for the Indian Forest Service, but others also may attend the forestry classes in order to qualify for the management of forests and woodlands in Great Britain and in the colonies. It may therefore be hoped that Dr. Schlich's manual will eventually promote the good management of forests in many parts of the world. In Great Britain and Ireland the author states the area of woods and forests at 2,790,000 acres, and in British India the area of Government forests at 70,000,000. No data are available for estimating the forest area in the British colonies. But the area stated is sufficient to demand the systematic teaching of forestry in England.

In the German Empire the total forest area only measures 34,346,000 acres, of which 11,243,000 acres belong to the State. Yet there are no less than nine forest schools in the different States for educating the superior officers in the State and other public forests and the principal wood managers in private estates. The books published on the subject of forestry in all its branches during the three years 1886–88 amounted to 177, or fifty-nine a year on an average. Besides these, there are ten periodicals on forestry, some quarterly, most monthly. One general association of German foresters meets annually, and ten local societies hold their meetings either annually or once in two years. And all these associations publish their transactions. Perhaps it will be urged that this large and daily-growing forest literature is not necessarily an advantage; that German foresters had better attend to the management of their forests instead of writing books. As a matter of fact, however, the management of the German forests, public as well as private, is excellent, and is improving steadily. The best proof of this is the large and steadily growing income derived from these estates by the Government, by towns and villages, and by private proprietors, and, more than that, the improved condition and the increased capital value of these properties.

A commencement, however, of forest literature has been made in the English language. The Transactions of the Royal Scottish Arboricultural Society have attained their twelfth volume, and they frequently contain papers of considerable importance. The *Indian Forester*, commenced as a quarterly by Dr. Schlich in 1875, is now a monthly magazine, of which fifteen volumes have appeared. In addition to these a number of valuable publications on different branches of forestry might be named that have been published within the last twenty-five years.

German forest literature, though it has attained such large dimensions, is of comparatively recent origin. During the eighteenth century sylviculture and the management of forestry had made great progress in many parts of the country, but the methodical and scientific treatment of the subject dates from the labours, during the first thirty years of the present century, of Hartig in Prussia, Cotta in Saxony, and Hundeshagen at Giessen. Scientific forestry in England must necessarily be built upon what has been accomplished in this respect in Germany, and with becoming modesty Dr. Schlich acknowledges that the principal German works have been his guide in the preparation of the present book. Great Britain does not stand alone in this respect. In France also the development of scientific forestry has to a great extent been based upon the progress previously made in Germany. The same may be said of forestry in Italy, Russia, Scandinavia, and other European countries.

Part I. of the manual treats of the utility of forests, directly in producing wood and other forest produce, and indirectly in influencing the climate, in the distribution of rain-water, in the preservation of the soil on sloping ground, in the binding of moving sands, and in affording shelter against winds. All these matters are clearly and ex-

haustively treated, and in regard to the climatic influence of forests the author gives a most useful summary of the researches which have been made to determine the effect of forest growth upon the temperature of air and soil, rainfall, humidity, and evaporation, in Germany, Switzerland, and France, mainly by the establishment of parallel stations, one being situated inside a fully stocked forest and the other at some distance in the adjoining open country.

Part II. sets forth the fundamental principles of sylviculture. The author maintains, with justice, that the principles of sylviculture hold good all over the world, but adds that the illustration of these principles must be taken from a limited area. For this purpose he has chosen the timber trees of Western Europe on the 50th degree of north latitude, and the countries immediately to the north and south of it—in other words, the forest trees of England, Northern France, and the greater part of Germany. These species the author does not attempt to describe; he assumes that his readers are familiar with them. The first chapter dwells upon the external conditions which influence the development of forests. He says:—

"Soil, including subsoil, and atmosphere are the media which act upon forest vegetation, and they together are in sylviculture called the 'locality.' The active agencies, or factors, of the locality depend on the nature of the soil and the climate, the latter being governed by the situation. The sum total of these factors represents the quality or yield-capacity of the locality. The forester requires to be well acquainted with the manner in which soil and climate act on forest vegetation, in order to decide in each case which species and method of treatment are best adapted, under a given set of conditions, to yield the most favourable results."

Every forester knows that on good soil, and under conditions otherwise favourable, a timber crop is heavier than one of equal age grown under less favourable conditions. In the concluding section of this chapter the author shows how one may use this fact in order to assess the quality of a locality. Numerous measurements of woods of different species and ages, grown under different conditions, have been made in Germany on a systematic plan, and from the data thus obtained yield tables have been calculated, showing the volume of timber produced at different ages on a given area by the principal species on localities of different quality classes. Using the yield tables published for the Scotch pine by Wilhelm Weise, now Professor at the Forest School of Karlsruhe, the author shows that at the ages of 50 and 120 years the volume per acre of timber only, not including faggots, in localities, which according to their yield-capacity are classed as first, second, and third class, is as follows:—

	I.	II.	III.
Cubic feet at the age of 50 years	5060	3940	2700
,, ,, 120 ,,	9060	6950	5340

The figures of these yield tables Dr. Schlich has found to a certain extent to be applicable to Scotch pine forests in England. They can therefore be used in order to assess the yield-capacity of any locality stocked with Scotch pine. Eventually, similar yield tables will doubtless be prepared for the Scotch pine and other forest trees in Great Britain, and it will then be possible with certainty to say what yield of timber may be expected from plantations made in a certain locality.

The second chapter deals with the shape and development of forest trees, but we can refer only to what the author says regarding height-growth. Building again chiefly upon researches made in Germany, Dr. Schlich explains how the different species have a different mode of height-growth. On p. 163 an instructive diagram will be found exhibiting the relative height-growth of spruce, silver fir, beech, and Scotch pine, in a locality of the first quality. At the age of 50 years the mean height attained by each species is as follows:—

Scotch pine	64 feet
Beech	60 ,,
Spruce	55 ,,
Silver fir	40 ,,

At a later age spruce and silver fir take the lead, while beech and Scotch pine remain behind in the race; and when 120 years old the order of the species stands as follows:—

Spruce	118 feet
Silver fir	108 ,,
Beech	102 ,,
Scotch pine	97 ,,

Scotch pine and beech therefore make the principal height-growth during the first period of their life, whereas spruce and silver fir continue to grow vigorously in height to a much greater age, spruce more so than silver fir. The progress of height-growth of the different species is much affected by the character of the soil, by elevation, the more or less crowded state of the wood, and other circumstances, but under otherwise similar conditions it will always be found that deep, fresh fertile soil produces much taller trees than shallow, dry, or rocky soil.

In the third chapter, which deals with the character and composition of woods, the author points out that the object of sylviculture is not to rear isolated trees, but considerable masses of trees, forming more or less crowded woods. Pure woods consist of one species only, or of one species with a slight admixture of others, whereas mixed woods contain a mixture of two or more species. The advantages of mixed woods are clearly set forth, and the author's remarks on this subject may be specially recommended to the attention of proprietors and managers of woodlands in Great Britain.

The last and most important chapter deals with the sylvicultural systems—that is, the different methods under which the creation, regeneration, tending, and utilization of woods are effected. The three well-known classes are: first, high forest, originating in seedlings, either self-sown or artificially raised; second, coppice, which regenerates itself from coppice shoots; and third, coppice with standards, a combination of seedling and coppice forest. The modifications of these three main systems are numerous, and particularly the treatment of high forest has developed in a great variety of ways. On this subject we must refer the reader to the manual. These are matters which can hardly be fully understood without opportunities for obtaining practical experience of forests treated under the various systems described. Such opportunities may, to some extent, be found in Great Britain. The high forests of larch and Scotch pine in Scotland, raised by planting, are excellent, and in some

districts Scotch pine woods are regenerated by self-sown seedlings. The oak woods of the Forest of Dean, and the beech woods on the chalk downs of Buckinghamshire, are instances of high forests with different character and different method of treatment. Most instructive, again, are the natural oak forests in Sussex—coppice, with a large proportion of standards. So are the coppice woods of ash and sweet chestnut for the production of hop-poles in Kent, and the osier beds on the banks of the Thames. The difficulty is, that the treatment of these woods is entirely empirical, and that, without authentic statistical data regarding yield in timber, regarding income and outlay, no forest can properly be used for purposes of instruction. If the student wishes fully to understand this and other portions of the excellent manual before us, he must study the forests of Germany, public and private. This may be a disadvantage, but under the circumstances of the case it cannot be helped.

Appended to the first part of the book are two treatises which will be read with interest by those who may not care to study the more technical portion of the manual. They deal with forestry in Great Britain and Ireland and in British East India. The physical configuration of India, its climate and rainfall, the distribution of the forests, and the forest policy pursued by the Government of India during the last thirty years, are clearly set forth. The protection and systematic management of its forests are matters of the utmost importance for the welfare of the millions inhabiting the British Indian Empire, of infinitely greater importance than good forest management is for Germany or other countries of Europe. Enthusiastic foresters in India have long maintained that, by improving the condition of existing forests, so as to make them more dense and compact, by extending their area, and by creating forests where none exist at present, the rainfall in seasons of drought might be increased, and famines might thus be averted. Dr. Schlich fully discusses this subject, and states several cases in which the presence of dense forest growth seems to accompany an increased rainfall; but at the same time he fully explains the reasons why a final conclusion does not seem justified. The result is that, though the local influence of forests in lowering the temperature and preserving moisture is undeniable, we are not justified in hoping for an improvement of the Indian climate. The favourable influence of forests in India upon the irrigation from wells and tanks is, however, beyond doubt, and this is a vital question.

To illustrate the effect of forest growth in protecting loose soil on hill-sides, the author mentions the Siwalik hills at the foot of the North-West Himalaya. We quote his words:—

"Anyone who has ever stood on the hills behind Hushiarpur in the Punjab, and looked down upon the plain stretched out towards the south-west, has carried away an impression which he is not likely to forget. In that part the Siwalik range consists of an exceedingly friable rock, looking almost like sand baked together. Formerly, the range was covered with a growth of forest vegetation, but a number of years ago cattle owners settled in it, and under the combined attacks of man, cows, sheep, and goats, the natural growth disappeared, while the tread of the beasts tended to loosen the soil. The annual monsoon rains, though not heavy, soon commenced a process of erosion and of carrying away the surface soil. Gradually, small and then large ravines and torrents were formed, which have torn the hill range into the most fantastic shapes, while the *débris* has been carried into the plains, forming, commencing at the places where the torrents emerge into the plain, fan-shaped accumulations of sand which reach for miles into the plain, and which have already covered and rendered sterile extensive areas of formerly fertile fields. Indeed, one of these currents or drifts of sand has actually carried away a portion of the town of Hushiarpur. The evil has by no means reached its maximum extent, and if curative measures are not adopted at an early date, the progress of transporting the hill range into the plain will go on, until the greater part of the fertile plain stretching away from its foot has been rendered sterile."

The author might have added the denuded hills, and the rivers, formerly navigable, but now silted up, in the Ratnagiri district of Western India, and other similar instances.

That a country so populous as India requires immense quantities of timber, bamboos, and firewood, goes without saying. Among other articles of forest produce, cattle fodder is an important item. In the drier portions of the country the supply of grass, particularly during seasons of drought, is more plentiful under the shelter of trees than out in the open. In times of scarcity, grain can easily be carried long distances to provide food for the people, while cattle fodder cannot be so easily carried. As a matter of fact, where forests have been formed and protected in the drier parts of India, they have proved a great help in enabling the people to maintain their cattle in times of drought and scarcity.

In India the duty of taking action necessarily devolved upon the State. The result has been the formation of extensive forest estates, called reserved forests, which at present, the author states, aggregate 33,000,000 acres, or three times the area of State forests in the German Empire. If forest matters in India continue to be properly managed, these estates will not only secure the well-being of the people, but will be an important source of strength to the Government, financially and otherwise. As yet, the revenue which they yield is insignificant in relation to their extent. But it is growing steadily. Dr. Schlich shows that during the three years 1864-67 the average annual net revenue from the Government forests amounted to £106,615, and during the five years 1882-87 to £384,752; and he states it as his opinion that, twenty-five years hence, the net surplus will be four times the present amount. More important, however, than the annual revenue is the steadily increasing capital value of these Government forest estates.

In Great Britain the aspect of affairs is different. The small area of the Crown forests, burdened as they are with prescriptive rights, cannot reasonably be expected materially to help the development of systematic forest management. But there are over 2,500,000 acres of woods and forests in the hands of private proprietors, and there are 26,000,000 acres of barren mountain land and waste, a portion of which might be planted up. Proprietors, as a rule, desire to augment their income and to increase the capital value of their estates. In many cases this might be effected by a more systematic management of their woodlands, and by the planting up of waste lands. The chief obstacle to progress in this direction is the low

price of timber and the high rent at present obtained by the letting of grouse moors and deer forests.

Upon data which cannot be gainsaid, Dr. Schlich has based important calculations, which will be found on pp. 17-19. Space forbids the discussion of details, but the result is that Scotch pine forests cannot be expected to yield more than $2\frac{1}{2}$ per cent. on the capital invested (the value of the land and of the growing crop).

"All land, therefore, which can be let for the raising of field crops, for shooting, or other purposes, at a rental equal to, or upwards of, $2\frac{1}{2}$ per cent. of the capital value of the land, had better be so let. On the other hand, land which would realize a rental of less than $2\frac{1}{2}$ per cent. of its value, may with advantage be planted with Scotch pine or other similarly remunerative trees."

These conclusions are based upon circumstances as they exist at the present time. But a change of circumstances is not impossible. The author points out that 6,000,000 loads of timber are imported annually into the United Kingdom from Europe and North America, and that only a small portion of the forests which furnish this large supply are under systematic management and control. It may be regarded as certain that the supply from Sweden and Norway and from North America, amounting at present to nearly 4,000,000 loads a year, will continue to diminish, and, under the circumstances of the case, the necessary result of such diminution will eventually be a rise in the price of timber. Again, if proprietors of woodlands in England and Scotland were in a position to offer large quantities of home-grown timber of good quality for sale, regularly at stated seasons, timber traders would make their arrangements accordingly, and in many cases better prices would be obtained. Firewood is at present almost unsaleable in the United Kingdom, but if—and this may happen—the price of coal should rise considerably, firewood would in some districts become an article of general consumption, as it was 150 years ago, and to some extent this would improve the money yield of woodlands.

It is not too much to say that the publication of Dr. Schlich's manual will give a powerful impetus to systematic forest management in the United Kingdom, in India, and in the vast colonies of the British Empire—in fact, wherever the English language is spoken.

D. BRANDIS.

FERREL'S THEORY OF THE WINDS.

A Popular Treatise on the Winds. Comprising the General Motions of the Atmosphere, Monsoons, Cyclones, Tornadoes, Waterspouts, Hailstorms, &c. By William Ferrel, M.A., Ph.D., &c. (New York: John Wiley and Sons. London: Macmillan and Co. 1889.)

NUMEROUS as are the popular treatises on various branches of phenomenal meteorology that have appeared during the last quarter of a century, English literature has hitherto been singularly deficient in elementary works treating of the physical and mechanical processes of the atmosphere from a theoretical point of view, and suited to the capacity of the average student. Those versed in the higher mathematics may indeed find all they require in such modern works as Sprung's "Lehrbuch der Meteorologie," and Ferrel's "Recent Advances in Meteorology," the high merit and originality of which last are somewhat veiled under its more obtrusive title—"Part 2 of the Report of the Chief Signal Officer of the [U.S.] Army for 1885." But these works are hardly suited for popular instruction; and for that large class of students whose mathematical acquirements are more limited, but who nevertheless desire to understand the movements and internal changes of the atmosphere, and to interpret them rationally in accordance with mechanical and physical laws, there has hitherto been little guidance, save such as they may obtain from casual references to them in works devoted to the general teaching of these sciences. It is perhaps in consequence of this divorce of the deductive from the inductive treatment of meteorological subjects that the contributions of English observers to the science of meteorology bear but an insignificant proportion to the labour expended on observational work, and that so much of this work is abortive, and practically of little value, owing to the absence of guiding and suggestive theoretical knowledge.

It is, then, with no ordinary degree of satisfaction that we hail the publication of Prof. Ferrel's treatise, the title of which heads this notice. As the originator and discoverer of many of the most important problems dealt with in these pages, no one could be better fitted to explain them in terms suited to general comprehension, and this task he has performed with a completeness and lucidity which leave but little to be desired. The work is, as it professes to be, a "popular" treatise, but popular only in the higher sense of the word. A system of movements so complex as those of the earth's atmosphere cannot be made clear to anyone who is not capable of following a chain of close reasoning, or who is not prepared to bring to the study that concentrated attention that is requisite to master any problem in deductive science. But, these being granted, no further demand is made on the student than some familiarity with the elements of algebra, and the simplest conceptions of plane trigonometry and kinetics. The action of the mechanical and physical forces that determine and regulate the wind system of the globe is clearly explained in the first two chapters of the work.

The most important and original portion of the book is that which deals with the general circulation of the atmosphere, in relation to which the cyclones and anticyclones that cause the vicissitudes of local weather are but matters of subordinate detail. The magnitude of the work achieved by Prof. Ferrel in this field has hitherto been recognized only by the few. It is not too much to say that he has done for the theory of atmospheric circulation that which Young and Fresnel did for the theory of light; and that the influence of his work is not more generally reflected in the literature of the day, must be attributed to the want of some popular exposition of the theory.

Starting with the fundamental conditions of a great temperature difference between equatorial and polar regions and a rotating globe, and postulating in the first instance a uniform land or water surface, it is shown how the convective interchange of air set up by the former must result in producing two zones of maximum

pressure in about lat. 30° in both hemispheres, two principal minima at the poles, and a minor depression on the equator, together with strong west winds in middle and high latitudes, and an excess of easterly winds in equatorial regions. The two tropical zones of high pressure determine the polar limits of the trade winds, and the whole system oscillates in latitude with the changing declination of the sun. Further, as a consequence of the fact that the great mass of the land is restricted to the northern hemisphere, whereas the southern hemisphere presents a comparatively uninterrupted sea surface, on which the retarding friction is less than in the northern hemisphere, the west winds of middle and high latitudes are much stronger in the latter than in the former, and by their lateral pressure cause a slight displacement of the tropical zones of high pressure and the equatorial zone of low pressure to the north of their normal positions on a hypothetical uniform terrestrial surface.

The great modification and extension of Hadley's theory thus introduced by Prof. Ferrel depends mainly on two points of the first importance. By all previous writers it was assumed that a mass of air at rest relatively to the earth's surface on the equator, if suddenly transferred to some higher latitude—say, *e.g.*, 60°—would have a relative easterly movement in that latitude equal to the difference of rotary velocities on the equator and on the 60th parallel, or about 500 miles an hour, the difference being proportional to that of the cosines of the latitudes. This, however, would be true only in the case of rectilinear motion. In reality, as Prof. Ferrel was the first to demonstrate, the mass of air would obey the law of the preservation of areas, like all bodies revolving under the influence of a central force, and its relative eastward velocity in latitude 60° would be 1500 miles an hour, being as the difference of the squares of the cosines. If, on the other hand, any mass of air at rest in latitude 60° were suddenly transferred to the equator, it would have a relative westerly movement of 750 miles an hour, and any mass of matter whatever moving along a meridian is either deflected—or if, like a railway train or a river between high banks, it is not free to yield to the deflecting force, presses—to the right of its path in the northern, and to the left in the southern, hemisphere.

The second point first established by Prof. Ferrel is that, in virtue of centrifugal force, this deflection or pressure to the right in the northern, and to the left in the southern, hemisphere is suffered in exactly the same degree by bodies moving due east and due west, or along a parallel of latitude, and therefore also in all intermediate azimuths.

From the first of these principles it will be readily seen why the west winds of middle latitudes are so much stronger than the easterly winds of the equatorial zone; and from the second, how these opposite winds, by their mutual pressure, produce the tropical zones of high barometer and the polar and equatorial regions of low barometer.

In subsequent chapters are discussed the modes in which the general circulation of the globe affects the climates of different latitudes by determining the distribution of rainfall in wet and dry zones, and inequalities of temperature through the agency of marine currents. Also the causes that modify and disturb the regularity of the ideal system, the chief of which is the mutual interaction of expanses of land and sea. The general excellence of these demonstrations is indisputable, but we have marked one or two passages which appear to us to be of doubtful validity, and which we recommend to the reconsideration of the author when the time comes, as we doubt not it will ere long, for the issue of a second edition of his work.

The first point to which we would take exception is what seems to us the too great influence ascribed to mountain-chains in deflecting the great atmospheric currents. That they deflect the surface winds, like other irregularities of the surface, and in proportion to their magnitude, is, of course, a matter of universal experience; but, in the absence of other causes operating to produce a diversion of the greater currents, their action in this respect appears to us to be merely local. As an instance we will take the case of the Western Ghats of India, an escarpment from 3000 to 7000 feet in height, running athwart the direction of the summer monsoon of the Arabian Sea. The wind charts of the Arabian Sea, issued by the Indian Meteorological Office, show no appreciable deflection of the monsoon wind on the windward face of this range; and if the same cannot be asserted of the corresponding wind in the north of the Bay of Bengal, where it impinges on the coast range of Arakan, it is evident that the deflection of this current to north, and eventually to north-west, is caused by the indraught towards the heated plains of Northern India.

We believe that a similar explanation will be found to hold good in all the more conspicuous cases cited by Prof. Ferrel. Thus, at p. 183 he says:—

"The air of the lower strata of the atmosphere in the trade-wind zone of the North Atlantic, having a westerly motion, and impinging against the high table-lands and mountain-ranges of Mexico, is deflected around towards the north over the south-eastern States, and up the Mississippi valley into the higher latitudes, where it combines with the general easterly flow of these latitudes, and adds to its strength. This completely breaks up the continuity of the tropical calm belt and dry zone, so that, instead of a dry region with scanty rainfall, such as is found in North Africa, Arabia, Persia, Beloochistan, and Cabul, we have on the same parallels in the southern and eastern United States a region of abundant rainfall, and all the way up the Mississippi valley and in the interior of the continent there is much more rain than in the interior of Asia."

Taking this passage as it stands, or only together with the immediate context, it might be understood to imply that the author ascribes this great diversion of the winds of the Gulf of Mexico, together with all the rainfall they bring to the southern States of America, solely to the influence of the comparatively low mountain-chain of Central America. That such, however, is not his meaning is evident from his subsequent remarks on p. 215, where, in describing the monsoons of North America, after noticing the high temperature of the land area in summer, he says:—

"On the southern and south-eastern coast, in connection with the deflection referred to [in the passage quoted above], it causes the prevailing winds to be southerly and south-easterly, instead of north easterly, as they would otherwise be in these trade-wind latitudes."

In point of fact, as may be seen on Dr. Hann's charts for January and July, in the new edition of Berghaus's "Physical Atlas," the diversion of the trade-winds of the Gulf of Mexico, northward up the Mississippi valley takes place only in the summer, and is an effect of the same agency, viz. the heating of the northern continents, that breaks up the high-pressure zone of the northern tropic into two anticyclones, one in each of the great oceans, and it is the juxtaposition of the Atlantic anticyclone and the Mexican cyclonic depression that determines the course of the winds and the resulting rainfall. To judge from the case of the Western Ghats, we think it may be safely concluded that, if there were no mountain-chain to the west of the Gulf, the results would not be greatly different. All the other instances quoted, illustrative of the diversion of great currents by mountain-chains, except such as are purely local, appear to us to be really due to other and similar causes.

In treating of the monsoons, Prof. Ferrel points out with perfect justice that their strength depends on the form of the land, and that they blow strongly only where the interior of the country is high and mountainous. But when he adduces Persia as an illustration of the negative case, we are unable to admit its relevancy. At p. 199 he observes:—

"In accordance with the preceding view of the principal cause of monsoons and land and sea breezes, it is seen from observation that all the great monsoons and the strongest land and sea breezes are found—the former in countries and on oceans adjacent to high mountain-ranges, and the latter along coasts with high mountains in the background. Neither the heated interior in summer of the Great Sahara of Northern Africa, nor of Arabia and Persia, which is considered the warmest region on the globe, causes, during this season of the year, any great indraught of air. It is true that at this season the north-westerly winds prevail a little more on the north-west coast of Africa and the ocean adjacent, due, no doubt, to the influence of the highly-heated desert of the Sahara; but over Arabia and Persia the north-west winds continue to blow almost incessantly, during June and July, away from the interior toward the Arabian Sea. . . . The monsoon influence, therefore, of countries mostly level, without an elevated interior, however highly they may become heated in summer or cooled in winter, is not very great."

But the interior of Persia is a part of the great tableland of Iran, and, to quote the description of Sir Oliver St. John, "its average height above the sea may be about 4000 feet, varying from 8000 or higher in certain of the outer valleys to not more than 500 in the most depressed portions of its centre." Its average elevation is therefore much greater than that of the interior of India, very much greater than that of the Indo-Gangetic plain, which is the goal of the Indian monsoon, and, as a glance at the map will show, it is not deficient in mountains. The explanation of the fact that, instead of attracting the monsoon from the Arabian Sea, it is itself swept by north-west and west winds—blowing, not, indeed, towards the Arabian Sea, but towards the lower Indus valley—must then be sought for elsewhere. The true explanation appears to us to lie in a combination of causes. Partly, perhaps, in the latitude, which brings it within the zone of the strong easterly current of extra-tropical regions, which, by its right-handed pressure, must resist any indraught from the Arabian Sea; but chiefly in the fact that any tendency that the heated highlands of Persia may have to create such an indraught is overborne by the stronger set towards India. For the latter country reaches far down into the tropics, and the centre towards which the monsoon blows must be determined by the resultant of all the temperature gradients of the whole heated region. An eastward direction having been given to the monsoon at the outset, its strength in that direction is greatly increased by the energy set free in the Indian monsoon rainfall.

This question is one of more than theoretical importance. These west winds of Persia and Afghanistan are the dry winds of Northern and Western India, and when they prevail beyond their normal limits, over the north of the Arabian Sea and a great part of India itself, to the exclusion of the rain-bearing current, they bring the drought and consequent dearth that have made India so disastrously notorious for its famines. Possibly, the explanation of their abnormal extension may be looked for in those oscillations of the great polar cyclonic systems to which Prof. Ferrel alludes at p. 339 of his work.

Cyclones and tornadoes are treated at great length, each of these subjects occupying more than one hundred pages of the book; and in connection with the latter is given the author's theory of the formation of hail, a subject which has hitherto been less understood than almost any other phenomenon of the atmosphere. It will be best given in the author's own words:—

"In the ascending current of a tornado, as in that of the equatorial calm belt, or of a cyclone, the rain-drops are formed down in the cloud region, and carried upward until they become too large to be supported by the current and so fall to the earth. . . . In a tornado, however, the ascending current is often so strong that the rain is supported until, by the blending of the small drops by coming in contact, very large drops are formed, and the strong ascending currents often extend so high that these large drops are carried away up into the region of freezing temperature. . . . There they are frozen, and after having been carried up and outward above to a distance from the centre, where the ascending current is not strong enough . . . to keep them up, they slowly descend, and receiving additions of ice as they fall, as long as their temperature remains below zero, . . . they finally fall to the earth as solid hailstones"

The concentric coatings so commonly observed in large hailstones are explained by these hailstones being carried again and again into the vortex by the strong indraught in the lower part of the storm-cloud, the theory being that every hail-cloud is a tornado, although it may not reach down to the lower atmosphere. The vapour being condensed as water in the lower part of the vortex, which is frozen at a higher level, and as snow in the upper part, each pair of coatings indicate an additional ascent through the storm-cloud. This view, which, even at first sight, seems far more reasonable than any previous theory, has received unexpected confirmation from the experience of more than one adventurous balloonist, more especially that of Mr. John Wise, whose fate it was to be drawn seven times successively into the vortex of a hail-cloud, and carried up repeatedly until the balloon was thrown out at the top. The account is, unfortunately, too long for extracting.

From what has been said, it will be apparent that Prof. Ferrel's book enters very fully into the many important topics enumerated in the title. Indeed, its subject-matter covers very much of the ground of which modern meteorology usually takes cognizance, and in the thoroughness of its treatment we know of no modern work in our language that can be brought into comparison with it.

H. F. B.

A NEW ATLAS OF ALGÆ.

Atlas deutscher Meeresalgen. Heft I. Von Dr. J. Reinke (Berlin: Paul Parey, 1889).

THE German Government, operating through the Kommission zur wissenschaftlichen Untersuchung der deutschen Meere, has undertaken to bear the cost of producing this sumptuous "Atlas" in the interests of fishery, and students of phycology have to thank an economic aspect of their study for a very remarkable addition to the literature of it. Similarly, we are indebted to the United States Fish Commission for the publication of Prof. Farlow's "New England Algæ."

It may be said at once that Dr. Reinke's "Atlas" is a success in every way, its level being that of Bornet and Thuret's "Études Phycologiques." From the point of view of *technique*, the plates are splendidly done, and the rest of the publication is worthy of them. This first part contains twenty-five quarto plates, and the text belonging to them consists of descriptions of the Algæ figured and special descriptions of the illustrations. Speaking not merely from an inspection of the book, but from a knowledge of the material of much of it communicated by Dr. Reinke to the British Museum, I do not hesitate to state that every one of these figures has great value to phycologists. They are not mere portraits of Algæ, taken from specimens more or less at haphazard, as is too much the fashion, but they represent faithfully characteristic stages in the development of the organisms in point. What is commonly termed "microscopical detail" fills the "Atlas," and one can hardly imagine it better done. In this portion the author (who has had the assistance of Dr. F. Schütt and P. Kuckuck) deals prominently with the Phæophyceæ, which, it is well known, are his particular study at present. Many of them are types of his own discovery, and generally unknown to workers in this field until this satisfactory introduction to them. Since they are of special importance to our native phycologists as Algæ of the North Sea and Baltic, a list is given of them :—

Halothrix lumbricalis, Kütz., *Symphoricoccus radians*, Rke., *Kjellmania sorifera*, Rke., *Asperococcus echinatus*, Mert., var. *filiformis*, Rke., *Ralfsia verrucosa*, Aresch., *R. clavata*, Carm., *Microspongium gelatinosum*, Rke., *Leptonema fasciculatum*, Rke., var. *uncinatum*, var. *majus*, var. *flagellare*, *Desmotrichum undulatum*, J. Ag., *D. balticum*, Kütz., *D. scopulorum*, Rke., *Scytosiphon pygmæus*, Rke., *Ascocyclus reptans*, Cr., *A. ocellatus*, Kütz., *A. balticus*, Rke., *A. fœcundus*, Strömf., var. *seriatus*, Rke., *A. globosus*, Rke., *Ectocarpus sphæricus*, Derb. et Sol., *E. Stilophoræ*, Cr., *E. repens*, Rke., *E. ovatus*, Kjellm., var. *arachnoideus*, Rke., *Rhodochorton chantransioides*, Rke., *Antithamnion boreale*, Gobi, var. *balticum*, Rke., *Blastophysa rhizopus*, Rke., *Epicladia Flustræ*, Rke., *Cladophora pygmæa*, Rke., *Pringsheimia scutata*, Rke.

It may be anticipated that a fair number of the novelties among these so-called "German Algæ" (the title reminds one of the "Protestant trout") may be found on our own coasts.

It should be mentioned that more systematic detail with reference to many of these is to be found in the author's "Algenflora des Westlichen Ostsee" (Berlin, 1889).

The author very properly calls attention to the fundamental importance of a thorough knowledge of marine Algæ to fishery, since the plant world prepares by its organs of assimilation the food of the animal world in the sea. The German Commission deserve the highest praise for the enlightened view of their functions embodied in this undertaking, and no biologist will grudge the warmest encouragement to Dr. Reinke in his work. It is anticipated that the book, when complete, will contain a hundred plates, with the accompanying text. In these days, when the most unmitigated rubbish frequently comes to us with highly pretentious illustrations, the student has learned to be on his guard against "prepossessing appearances." No *plate manufacture*, however, can produce the welcome impression of weight and importance stamped on this "Atlas," gained to a great extent by the fact that Dr. Schütt and Herr Kuckuck, who have drawn the plates, have given us the work of skilful botanists, and not that of draughtsmen only.

G. M.

OUR BOOK SHELF.

Die mikroskopische Beschaffenheit der Meteoriten erläutert durch photographische Abbildungen. Von G. Tschermak. (Stuttgart: E. Schweizerbart'sche Verlagshandlung [E. Koch], 1883–85.)

Die Structur und Zusammensetzung der Meteoreisen erläutert durch photographische Abbildungen geätzter Schnittflächen. Von A. Brezina und E. Cohen. (Stuttgart: E. Schweizerbart'sche Verlagshandlung [E. Koch], 1886–87.)

Die Meteoritensammlung des k. k. mineralog. Hofkabinetes in Wien. Von A. Brezina. (Wien: Alfred Hölder, 1885.)

THE above three works together provide for the student a rich treasury of information relative to the characters of meteorites. The first two illustrate, by the aid of photography, the structure and composition of the more typical meteoric stones and irons respectively. The work dealing with the meteoric stones is complete in three parts, including 25 large plates, and has been undertaken by Prof. Tschermak, who had charge of the Vienna Collection of Minerals from 1869 to 1877. Of that which relates to the meteoric irons only two parts have as yet appeared, but they comprise no fewer than 24 large plates: it is undertaken jointly by Dr. Brezina, who succeeded Prof. Tschermak in the keepership of the Vienna Collection, and by Prof. E. Cohen, of Greifswald, whose series of micro-photographs of sections of terrestrial minerals and rocks is so well known.

Photography has rarely been applied to a more satisfactory purpose than the multiplication of exact representations either of transparent meteoritic sections, or of etched meteoric irons as seen with the unassisted eye or when magnified by means of the microscope. Meteoritic falls are rarely so large that the market is flooded with

illustrative specimens; and, indeed, a good collection of typical meteorites is inaccessible to most students. But, further, meteoric irons are very prone to deteriorate, through oxidation, and the perpetuation of the characters of a freshly etched face is thus especially to be desired. The excellence of the photographs is beyond all praise. The details, whether of the chondritic structure or of the Widmanstätten figures, are most beautifully shown. A brief description of the salient features of the sections is furnished with each plate.

The third work is nominally a Catalogue of the Vienna Meteorites, but, by reason of the completeness of that collection, is virtually a survey of the petrographical characters of the meteorites of all the known falls. The classification adopted is in the main that suggested by Gustav Rose in 1864, and developed by Tschermak in 1872 and 1883. The detailed description and definition of the groups is preceded by a history of the Vienna Collection, and also by a sketch of the various theories which have been proposed relative to the mode of formation of meteorites. As a result of his microscopical researches, Dr. Brezina supports the view that the structural features of meteorites are due to hurried crystallization, and not to a slow agglomeration of fragmentary matter. Dr. Brezina adds a chronological list of the meteorites preserved in the known collections, and also a lengthy index of names, synonyms, and localities. The work extends over 126 pages, and is accompanied by four plates. L. F.

Introduction to Chemical Science. By R. P. Williams A.M., and B. P. Lascelles, M.A, F.C.S. (London: Ginn and Company, 1889.)

THERE could hardly be a more concise and well-digested summary of elementary chemical principles and applications than that contained in this work. It is a manual intermediate between the natural philosophy primer and the minute and detailed text-book, and fills the gap pointed out in the Report on Chemical Teaching of a British Association Committee in 1888. Hence, as an outline of chemical science to be filled up in greater detail from larger works, and as an introductory text-book, this volume will be found exceedingly useful. The experiments described are such as should be performed by everyone beginning the study of chemistry, and would also serve as an excellent introduction to a course of qualitative analysis. In addition to the treatment of metals and non-metals, the work includes chapters on organic chemistry, and others on photographic chemistry, the chemistry of rocks, and electro-chemistry. Indeed, Mr. Williams, the author of the American edition, and the reviser, Mr. Lascelles, may claim to have produced a most comprehensive little work, and one deserving considerable commendation.

The Cradle of the Aryans. By Gerald H. Rendall, M.A. (London: Macmillan and Co., 1889.)

THE question as to the primitive home of the so-called Aryan race has lately excited so much interest that many students must have wished for a short and clear account of the controversies relating to the subject. This is exactly what Prof. Rendall supplies in the present essay, the substance of which was originally communicated to the members of the Liverpool Literary and Philosophical Society. Prof. Rendall accepts Penka's theory that the Aryans were a European people who, at the close of the glacial epoch, followed the ice northwards, and settled in Scandinavia; and that Scandinavia was the centre from which, at various subsequent periods, groups of the Aryan race were dispersed. All the arguments marshalled by the German writer in favour of this hypothesis are here briefly and effectively stated. The philological part of the case is presented in a more scholarlike spirit by Prof. Rendall than by Penka himself, whose rash philological conjectures have prevented a good many people from doing full justice to the weight of his anthropological and ethnological evidence.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Mr. Cope on the Causes of Variation.

MR. E. D. COPE'S letter in NATURE of November 28 (p. 79) is a fair sample of his writings on biological theory, in so far as I am acquainted with them.

Mr. Cope proposes to teach Mr. Wallace and others the first principles of both logic and biology. The tone of his letter encourages a similar frankness in reply. Mr. Cope must not take it amiss when he is charged with two of the gravest faults of which a critic can be guilty—namely, complete misapprehension of the matter which he is attempting to criticize, and no less complete ignorance of the recognized and elementary facts of the branch of science to which that particular matter relates. I do not hesitate to assert that Mr. Cope puts forward an argument which could not possibly be entertained by anyone who is acquainted with the most notorious and admitted facts of heredity and variation. I venture to express myself thus emphatically, because it is a matter for sincere regret that American biology should at this moment be identified with what is sometimes called "a school of philosophy" which owes its distinction to a deliberate ignoring of the writings of Mr. Darwin. By all means let us have discussion and criticism of Mr. Darwin's conclusions, but let it be understood that those who enter upon such discussion have at any rate an elementary acquaintance with the works of Mr. Darwin himself, if not with those of Weismann and Wallace; otherwise, much time and much of your valuable space will be wasted.

That Mr. Cope has not the necessary elementary acquaintance with the admitted facts of heredity and variation will appear from what follows. The discussion in which he has intervened is one as to whether certain structural peculiarities exhibited by flat-fish are due to the transmission to their offspring of a form and position of parts *acquired* by muscular efforts by the ancestors of flat-fish, or whether these given structural peculiarities suddenly appeared in the ancestors of flat-fish as a "congenital variation" having no adaptive relation to any efforts or experiences of a preceding generation, and were advantageous to their possessors, so that the individuals thus born were favoured in the struggle for existence, survived to maturity, and transmitted their peculiarity to some of their offspring with such intensification as is found experimentally to be the result of breeding from parents both of which possess a given congenital peculiarity.

The question raised is, in short, whether in this case Lamarck's *hypothesis* of the transmission of acquired characters is the necessary explanation, or whether the case can be explained by the action of the *known* causes (not hypothetical causes) on which Mr. Darwin founded his theory of the origin of species, viz. the occurrence of congenital variations unrelated to any like variations in parents or ancestors, and the selection and intensification of such variations in subsequent breeding. There has been here no ambiguity—such as unfortunately arises sometimes when like questions are discussed—as to the sense in which the term "acquired characters" is used. It is clear enough that by the "acquired characters" of a parent we do not mean characters congenital in the parent, but expressly exclude them; it is clear that we refer on the contrary (as did Lamarck) to new characters acquired by the parent as the direct consequence of the action of the environment upon the parental structure, and exhibited by that parent as definite measurable features.

Now let us consider Mr. Cope's contribution to the discussion. He accuses Mr. Wallace—who is one of those who refuse to adopt Lamarck's gratuitous hypothesis of the transmission of acquired characters—of being guilty of the sin of "non-sequitur" and "paralogism." He then proceeds to make a general statement, the truth of which neo-Darwinians (or post-Darwinians, or anti-Lamarckians), in common with all men, recognize,

although Mr. Cope offensively implies that they do not, viz. "Selection cannot be the cause of those conditions which are prior to selection: in other words, a selection cannot explain the *origin* of anything." How can Mr. Cope presume to tell us this? Who has ignored it? when? and where? Mr. Cope does not seem to be aware of the fact that the anti-Lamarckians attach great importance to the existence of congenital variation, that Darwin himself has written at length on the subject, and that Weismann has developed a most ingenious theory as to the relation of fertilization and its precedent phenomena to this all-important factor in evolution.

Mr. Cope puts aside all that has been done on that subject, or else is ignorant of it, and calmly lays down the following proposition: "If whatever is acquired by one generation were not transmitted to the next, no progress in the evolution of a character could possibly occur. Each generation would start exactly where the preceding one did." The full significance of this sentence can only be apprehended when it is understood that Mr. Cope believes that progress in the evolution of a character *does* occur. The statement therefore amounts to this: (1) that whatever is acquired by one generation is transmitted to the next; and (2) that the only possible explanation of the fact that a new generation does not exactly resemble its parents at a corresponding age is that the parental generation has transmitted to its offspring particular features acquired by it between birth and maturity.

I doubt whether Mr. Cope will find any other naturalist—even the most ardent Lamarckian—to join him in these assertions.

With regard to the first, it is hardly necessary to say that it has never yet been shown experimentally that *anything* acquired by one generation is transmitted to the next (putting aside parasitic diseases); and as to *everything* ("whatever") being so transmitted, every layman knows the contrary to be true. Children are not born with the acquired knowledge of their parents. If there were no other explanation offered of offspring varying from their parents at a like age than the hypothesis of transmission of characters acquired by the parents on their way through life by the action of the environment, this hypothetical explanation would still be quite insufficient to account for the fact that the individuals of one brood vary enormously as compared with one another, a fact which points to the individual germs (egg-cells and sperm-cells) as the seat of the processes which result in variation, and not to the parental body which is the common carrier of them all. Assuredly these broods demonstrate that *all* the acquired characters are not transmitted to *all* the offspring.

With regard to the second proposition which Mr. Cope's statement contains, experimental fact is directly opposed to its truth As cited by Darwin on p. 8 of the first edition of the "Origin of Species," Geoffroy St. Hilaire showed that "unnatural treatment of the embryo causes monstrosities; and monstrosities cannot be separated by any clear line of distinction from mere variations." Mr. Darwin himself was "strongly inclined to suspect that the most frequent cause of variability may be attributed to the male and female reproductive elements having been affected prior to the act of conception." What he meant by "being affected" is explained at greater length in the "Animals and Plants under Domestication," where, in chap. xxii., there is a long discussion of the causes of variability, the conclusions of which are supported by an array of observed facts which Mr. Cope cannot be permitted to ignore at his pleasure. Mr. Darwin there gives solid reasons (as was his wont) for holding that variability results from the conditions to which the parents have been exposed: changes of any kind in the conditions of life, even extremely slight changes, often suffice to cause variability. But Mr. Darwin's examination of the facts did not lead him to conclude that the bodily characters acquired by the parents as the result of changes were those which manifested themselves as variations in the offspring. On the contrary he showed that the effect of changed conditions, of excess of nutriment, and of the crossing of distinct forms, is a "breaking down," as it were, of the hitherto fixed characters of the race, leading to the reappearance of long-lost characters and to the appearance of absolutely new characters, the new characters having no more (and perhaps not less) relation to the exciting cause which acted through the parent than has the newly-formed pattern in a kaleidoscope to the tap on the kaleidoscope tube which initiated the rearrangement.

For Mr. Cope to complain of the methods of reasoning of post-Darwinians, and at the same time without any reasoning at all to assert (as he does, not directly but by implication) that there is no such thing as "congenital variation" or "sporting," is not quite satisfactory. When it is asserted that every feature by which a young animal differs from the structure of its parents at a corresponding age must have been acquired by one or other of the parents as actual structural features, and so transmitted as an acquired character to the offspring, the whole world of fanciers, horticulturists, farmers, and breeders, is ready with its unanimous testimony to contradict the assertion.

Let me say, in conclusion, that, as Mr. Wallace has pointed out, Mr. Darwin did not consider that variability in a state of nature was either so general or so wide in its range as later observations and reflections lead us to believe it to be. Mr. Darwin studied those causes which are found by practical gardeners and breeders to be favourable to excessive variation in animals and plants under domestication. He showed clearly that the resulting variations had no adaptive relation to the exciting causes, and were manifested in the structure at birth of a new generation, and not in that of the generation subjected to the exciting cause. No one has yet been able to give an adequate account of the frequency and range of variation of any number of animals or plants in a state of nature, because natural conditions destroy, on the average, all individuals born of two parents—except two—before maturity is reached, and those two are naturally selected in consequence of their adhesion to the specific type.

There can be no doubt from a consideration of the facts cited by Darwin that, whilst variation often is reduced to a *minimum* in natural conditions which remain constant, natural variations of conditions can and do occur, which excite the germ-cell and sperm-cell, or their united product, to vary as in conditions of domestication. There can be no doubt that there was in Mr. Darwin's mind the conception of a definite relation between two effects arising from changed conditions: the one being the disturbance of the equilibrium of the organism and its consequent production of variations; the other being the new requirements for survival; in fact, there seems to be, as it were, at once a new deal and new rules of the game. It is not difficult to suggest possible ways in which the changed conditions shown to be important by Darwin could act through the parental body upon the nuclear matter of egg-cell and sperm-cell, with its immensely complex and therefore unstable molecular constitution, so as to bring about *variations* (arbitrary, kaleidoscopic variations) in the ultimate product of the union of the remnant of the twice-divided threads of the egg-nucleus with the nuclear head of a spermatozoon. The wonder is, not that variation occurs, but that it is not excessive and monstrous in every product of fertilization. And yet Mr. Cope writes from the other side of the Atlantic to assert that there is no possible cause of departure from parental type in offspring, excepting that assumed in Lamarck's unproved, improbable speculation! E. RAY LANKESTER.

December 7.

Protective Coloration of Eggs.

SOME years ago an idea similar to that of your correspondent, Mr. Grensted (November 21, p. 53), occurred to me, as regards the protective coloration of eggs; and, curiously enough, the red-backed shrike was one of the birds whose eggs I selected for special observation. My experience has been that the ground colour of these eggs is quite arbitrary. I fear that I cannot furnish data, as I ought; but I well remember that I found in Sussex a rather abnormally pale clutch of eggs in a very dark nest; and that I regarded this, at the time, as completely doing away with my hypothesis. The evidence that I got from other, less striking instances, told about equally for and against.

Another egg, whose variations I watched pretty closely, was that of the yellowhammer. Apart from differences of marking, the ground-colour of this egg varies from pure or pinkish white, to a white rather deeply suffused with purplish-red or olive-brown. But in this case, again, the correspondence of colour between the egg and its surroundings could not be made out at all satisfactorily.

A pale and little-marked specimen of the egg of the spotted flycatcher, that was brought in to me one spring at Malvern, suggested to me that it would be worth while to observe the variations here also. But I again failed to arrive at any conclusion.

I am so strongly tempted unreservedly to accept the "protective" theory, that I perhaps lay too great stress on these negative instances. As a matter of fact, I suppose that the experience of a single individual is rarely large enough to justify any induction being made from it. I myself, for instance, have never come across the extreme variations of the cuckoo's egg, such as Seebohm figures. E. B. TITCHENER.

3 Museum Terrace, Oxford, December 3.

Is the Bulk of Ocean Water a Fixed Quantity?

MR. MELLARD READE's criticism is perfectly sound. If the bulk of the ocean water on the surface of the globe has always been the same, the oceans could not at any time have been shallower than at present without a decrease in the area of the land. Consequently, the supposition that in early geological times the area of the land was larger, and the depth of the oceans less, demands the further inference that the bulk of the ocean water was less then than it is now.

When writing on the physics of the sub-oceanic crust, I saw that this was a necessary consequence of the theory, but I was not then quite prepared to discuss it. I have since had some correspondence with Prof. A. H. Green and Mr. O. Fisher on the subject, and will briefly indicate the possibilities that have occurred to us.

The first suggestion made was that, if the solar radiation was greater in Palæozoic times, there would be greater evaporation, and as the temperature of the air would also be higher, the atmosphere could hold more aqueous vapour than it does now, so that we might suppose a part of the water which is now in the ocean to have been then permanently suspended above it. Mr. Fisher, in writing to me, admits this possibility, and even thinks it might be feasible to estimately roughly the amount of water so suspended if the mean temperature of the ocean at any period was known. But he says:—"I do not think you could get much diminution of the oceans in this way, for, suppose the present atmosphere to consist of nothing but aqueous vapour, then it would represent a layer of water about 30 feet thick evaporated from the earth's surface. Now, it seems hardly probable that at a former time there should have been an amount of aqueous vapour in the atmosphere so great that the mass of such additional vapour should equal that of all the oxygen and nitrogen and vapour now in the atmosphere; and even if there was this amount, it would take off only about 30 feet of water from the surface of the globe," or about 37 feet from the present surface of the oceans.

If, therefore, the bulk of the water on and above the surface of the earth has remained the same since the time when the crust was first formed, it seems difficult to find any means of sensibly diminishing the amount of water in the oceans. But need we make this preliminary assumption, and is it not really possible that there has been an increase in the bulk of surface-water, and not a decrease by absorption, as some theorists would have us think? May we not suppose, in fact, that water-substance has always existed in the interior of the earth, and may it not, by its constant and gradual escape, have always been adding to the bulk of the surface-waters?

This idea had occurred to Mr. Fisher so long ago as 1873, and the following passage occurs a paper then published (Trans. Camb Phil. Soc., vol. xii., Part 2, p. 431): "If such was the condition of the interior in the early stages of the cosmogony, a large portion of the oceans now above the crust may once have been beneath it"; and in the new edition of his "Physics of the Earth's Crust" he further discusses the manner in which this water-substance may be diffused through the magma of the liquid substratum beneath the crust.

As a matter of fact, it is well known that almost all volcanoes, when in eruption, emit large quantities of steam, and the presence of this steam has always been connected with the causes of volcanic activity. There are only two ways of accounting for the presence of this steam: (1) that water from the sea or from the rainfall gains access to the deep-seated foci of volcanic action; (2) that the water-substance is a primary constituent of the liquid magma below, and that when this material is forced up to the surface, the pressure which kept the water in solution or combination is removed, and it is blown off as steam.

As regards the first possibility, there are great difficulties in the way of supposing that surface-water can find its way to any region where the heat is sufficient to keep rock constantly in a liquid condition. It does seem possible that the access of water to the interior parts of a volcano *already established* may sometimes cause an eruption, and, under certain circumstances, an eruption of great violence; but the descent of water through the earth's crust to depths of 20 or 30 miles so as to be the initial cause of the establishment of volcanoes is not so easy to understand. The pressure of the superincumbent rocks at a depth of 2 or 3 miles must be so great that all cracks and interstitial spaces would be reduced to a minimum, and at the depth of 5 miles one would suppose that none such could exist. Several facts are known to geologists which show that all cracks diminish rapidly downwards. One such fact is that in many deep mines the throw of a *fault* diminishes with the depth to which it is followed. Another is the existence of such warm springs as those of Bath, the explanation of which is supposed to be that water percolating downward (say from the Mendips) reaches a depth at which there is less resistance to its travelling laterally than to its further descent, and that ultimately reaching a crack or fault, it is forced up this path of least resistance by the hydrostatic pressure of the descending stream.

It is true that a residuum of the water might continue its downward journey, being, as it were, slowly sucked downward as far as the minutest interstitial spaces extended; but what would happen when it reached the lower layers of the crust? Could it possibly reach and be absorbed by or dissolved in the semi-fused rock which must there exist? Captain C. E. Dutton has well expressed this difficulty. Referring to the high temperature which must exist at a depth of 5 or 6 miles, he says:—"At such a temperature the siliceous materials of which the rocks are composed are no longer hard and brittle as when they are cold, but viscous and plastic. . . . Now a crack or fissure might reach very far down into hard, cold, brittle rocks, but into soft semi-fused plastic rocks, never. Under a pressure of several miles of superincumbent strata, a crack, or even the minutest vesicle, would be tightly closed up as if its walls were wax or butter. A more perfect packing against ingress of water could not be conceived." [1]

Even capillary action could not come into play under such conditions as these.

Let us next consider the alternative theory suggested by Mr. Fisher. He claims that geologists furnish him with a certain amount of positive evidence for the idea that water is an essential constituent of the liquid magma from which the igneous rocks have been derived. Passing over the proofs of the existence of water in the crystals of volcanic rocks and in the materials of deep-seated dykes, let us come at once to granite, a rock which can only have been formed at great depths and under great pressures, and which often forms large tracts that are supposed to have been subterranean lakes or cisterns of liquid matter in direct communication with still deeper reservoirs. Now, all granites contain crystals of quartz, and these crystals include numerous minute cavities which contain water and other liquids; and the quartz of some granites is so full of water-vesicles that Mr. Clifton Ward has said: "A thousand millions might easily be contained within a cubic inch of quartz, and sometimes the contained water must make up at least 5 per cent. of the whole volume of the containing quartz." This amount only represents the water that has been, as it were, accidentally shut up in the granite, for some was doubtless given off in the form of steam which made its way through the surrounding rocks.

It is therefore generally conceded that granite has consolidated from a state of igneo-aqueous fusion, and that the liquid magma from which all granitic intrusions have proceeded contains water-substance. It is therefore only a step further to assume that this water-substance is an essential constituent of the liquid substratum, and to suppose that it has been there since the consolidation of the earth. That there is no inherent improbability in this supposition, and that it is not inconsistent with chemical views of cosmogony, Mr. Fisher has shown at the end of his chapter on the "Liquid Substratum."

I am only now concerned with it as an explanation of the secular increase in the bulk of the ocean waters which is demanded by my theory of the evolution of continents and oceans. We can prove from the geological records that volcanic action has always been in operation from the very earliest times in the world's history, and if it is true that such a reservoir of water-substance has always existed in the earth's interior, the continual volcanic eruptions must have constantly added water to the oceans on the earth's surface. Hence, as I stated in my

[1] "Volcanoes," by C. E. Dutton, in *Ordnance Notes*, No. 343, Washington, 1889.

first letter, we are at liberty to imagine a time when there was much more land than there is at present, and when all the oceans were comparatively shallow. A. J. JUKES-BROWNE.

Galls.

BEFORE rushing into arguments on this subject, it appears to me that more good might be done by entering into investigations of the physiological and morphological problems involved.

A gall-fly of a particular species inserts an egg in a certain position on a certain plant (oak, for instance). Another gall-fly of a different species inserts its egg almost in the same position on the same plant. But the results are totally dissimilar. An abnormal growth is set up, from irritation, in either case; but the nature of this growth is quite different. The initial irritation is set up by the presence of the egg, and in most gall-insects the egg *grows*—that is to say, it increases vastly in size before the larva is hatched. The irritation is continued by the larva, and the gall is produced, varying in form in accordance with the species of gall-fly that deposited the egg. But I want to know in what consists the difference in the active irritation that causes so great a divergence in the results? I am not aware that this has ever been answered. But I am quite sure it could be answered on purely physiological grounds if carefully studied. The answer would not in the least detract from the importance of the point as regards natural selection; but it might very materially modify speculative theories based on results only, without a precise knowledge of the agencies that produced those results. R. MCLACHLAN.

Lewisham, November 29.

ALTHOUGH I see no need of a better explanation than Prof. Romanes's (NATURE, November 28, p. 80) of the difficulty which galls seem at first sight to present for natural selection, yet I beg leave to say some words of further elucidation.

When it was said by Darwin ("Origin of Species," chap. vi.): "If it could be proved that any part of the structure of any one species had been formed for the exclusive good of another species, it would annihilate my theory, for such could not have been produced through natural selection," he evidently meant only species living without organic connection with each other, viz. his own example of the rattlesnake. The argument does by no means apply to organisms living in a relation of *symbiosis*, as is the case with gall-bearing plants and the larvæ inhabiting the galls.[1] Such associations form, as it were, one compound organism. Natural selection evidently may act in favour of each symbiont separately, provided only that the effect will not damage the other symbiont in such a degree as seriously to impair its existence. Some "disinterested" expenditure of energy and of organic substance is not excluded by natural selection, but may be promoted, if of advantage to the other partner. Thus the production of galls will scarcely do any serious injury to an oak, and even if such were sometimes the case, there would be no comparison to the damage worked, for instance, by Trichinæ, on the organism of man and animals, which hosts, nevertheless, in consequence of the stimulus caused by the parasite, afford the substance for capsules protecting the worms, just as plants produce manifold structures beneficial to the gall-insects. If Trichinæ would attack a species of mammals as frequently as, for instance, leaf-cutting ants attack some tropical plants, then those hosts would be forced either to develop, by survival of the fittest, some protection against their invasion, or they would succumb to the enemy and die out.

Analogous examples might be multiplied of both plants and animals, and it is especially to be remembered, as alluded to by Prof. Romanes, that the chemical activities of parasites, including the elaboration of ferments affecting the saps and tissues of the host, are as much under the guidance of natural selection as are their morphological variations. D. WETTERHAN.

Freiburg, Badenia, November 30.

WITH all due deference to your able correspondents Dr. St. George Mivart and Prof. G. J. Romanes, I cannot for the life of me understand how the theory of natural selection can be seriously assailed by investigations into the formation of galls by insects. Gall-formation has always appeared to me to be a pathological, that is a *perverted physiological* process, and to be due to the action of some animal irritant upon normal vegetable tissues during their period of active growth. These formations are therefore, to my mind, fairly on a par with the globular nests produced by the larvæ of the Œstrus, or bot-fly, in the hides of oxen; or to the inflammatory foci in the tissues of the kidneys, due to the translation of Bacilli, in the case of ulcerative endocarditis. Other examples bearing on the subject will doubtless occur to your readers. In all such instances we have certain changes in the cellular or protoplasmic tissue-elements of the host, brought about by the growth and development of a foreigner in their midst; and natural selection, in so far as it operates in such cases, seems to have sided mostly with the stranger, and to be to his advantage alone. That the host under these circumstances performs actions "which, if not self-sacrificing," are at least "disinterested," must be admitted; but it is the self-sacrifice of coercion and disinterestedness under compulsion. W. AINSLIE HOLLIS.

Brighton, December 1.

[1] Darwin's thorough acquaintance with these important structures is shown by his elaborate discussion in "Animals and Plants under Domestication," chap. xxiii. (2nd ed. vol. ii. p. 272). It is particularly to be noted that Darwin insists on the accordance of galls, for instance, on roses, with structures arising through bud-variation.

Luminous Night Clouds.

THE many inquiries and appeals regarding observations of luminous night clouds which have recently appeared in the columns of NATURE, and the growing importance of the subject, will justify me, perhaps, in sending to you, for publication in that journal, the following item, so long after the event it describes took place.

About the middle of November 1887, between eight and nine in the evening, as I was walking homewards from my day's work, I noticed what appeared to me to be the arch of a rainbow very low above the western horizon, and of a snow-white colour. A bank of clouds was rapidly approaching from the west, which, at the time of the first appearance of the arch, covered nearly half the sky, the eastern half being clear. The arch appeared to move eastwards, with and in the midst of the clouds, for it continually rose above the horizon, and, in the course of about half an hour, had approached the zenith.

At this time I called out several people to witness the phenomenon, which certainly presented a most extraordinary appearance. The arch appeared to be uniformly of about 3° or 4° in width, and extended north-north-east and south-south-west across the whole sky. The latter was about wholly overcast with the clouds at this time, except the arch, which presented a glaring brightness, and illuminated the earth with a weird splendour four or five times exceeding that of the brightest moonlight.

While at the zenith, the stars shone through the entire width of the arch with apparently more than ordinary brightness; but as the arch approached towards and receded from that point, the width of the transparency was observed to diminish rapidly with the distance, until at 10° or 15° on either side the stars were invisible through it.

The phenomenon appeared to be a division in the cloud stratum, the opposite walls of which were pretty clearly defined; and there appeared to be absolutely nothing between these opposite cloud walls but the purest air and the white light of the arch. I remember also that the wall or border of cloud on either side of the arch was slowly revolving upon an axis parallel with the arch; just as is often seen in the front bank of clouds of an approaching storm. But I do not remember the direction of the rotation, or whether both borders rotated in the same or in opposite directions.

The arch moved towards the east at about the same pace that it approached from the west, and with apparently the same width and direction of extension. There was no moonlight at the time, and only a gentle breeze was blowing. The weather preceding the phenomenon was fine for several weeks; but a few days afterwards, or on November 19, there was a sudden and extraordinary fall of the temperature, accompanied by some snow and very high wind.

I have thought that possibly this phenomenon might throw some light on the subject of luminous clouds, and that this tolerably accurate description of it may therefore be of interest to the students of that subject. I may add, however, that the luminosity of the arch did not appear to proceed directly from the clouds themselves, but from the clear space between the

clouds; although, according to the best of my recollection, luminous filaments seemed to extend from the clouds for a short distance into the span of the arch. EVAN MCLENNAN.

Brooklyn, Iowa, U.S.A., November 22.

Electrical Figures.

I RECENTLY noticed a pretty form of electrical discharge, which has probably been described before, but was new to me. Perhaps one of your readers will be able to refer us to an account of it.

The poles of a Voss machine are put very near together: a plate of ebonite $\frac{1}{40}$ inch thick is placed between them. As the machine works, a succession of delicate ramified discharges run over both surfaces of the plate: they are bright green, and each crooked line is discontinuous—a series of dashes, as if stitched out in silk, now above and now below the surface.

Winchester College, December 6. W. B. CROFT.

NEW DOUBLE STARS.

THE highest quality of seeing, as of acting or of thinking, needs initiative. A mental impulse is the spring of discovery, even by a purely visual process. The mind prompts the eye, interprets what it suggests, bodies out its semi-disclosures. So that to perceive what has never been perceived before is, in a sort of way, an act of *invention*. It thus happens that an accurate is not always an original observer. Novelties, as such, are almost inaccessible to many persons with exquisite powers of vision for whatever is already known to be within its range.

The late Baron Dembowski was an example of a first-rate observer but slightly endowed for detection; Mr. Burnham, on the other hand, is a born discoverer. The accidents of his career have turned his attention almost exclusively to double stars; and his glance seems to have a compulsive power of turning simple into compound objects by long and intent looking. His Chicago thousand of new pairs are famous; he bids fair to accumulate an equally imposing array at Lick. Nor does he neglect the old in the search for the new. The more exciting is not permitted to exclude what is in many respects the more useful occupation.

Progress in double-star astronomy is absolutely dependent upon remeasurements of the relative positions and distances of known pairs. We can otherwise learn nothing as to the nature of their connection. Inquiries about them can, by this means alone, be pushed through the three successive stages leading up towards complete knowledge. In the first place, it has to be decided whether the stars shift their places perceptibly with reference one to the other. If they are "fixed," but with a common proper motion, then they may safely be set down as physically coupled, although centuries may elapse before the character of their mutual revolutions becomes apparent. In the next place, the nature of relative motions, where they exist, has to be ascertained. Should they prove to be rectilinear, that fact alone overthrows the possibility of any real connection between the stars. Each pursues its way independently of the other. Finally, in the interesting cases in which curvilinear motion shows itself, persistent micrometrical measures are required to determine the shape and period of the orbit traced out.

Yet the majority of these objects receive little or no attention. This is in part due to their great numbers. About 12,000 double stars—using the term in the widest sense—are now known; nearly 5000 are in really close conjunction—so close, in some 1400 instances, as to render the chances of accidental juxtaposition all but evanescent. Only between fifty and sixty stellar orbits have, however, as yet been computed, and many of them from most inadequate data. The truth is, that this branch of work wants organizing. It is too vast and too important to be abandoned to the capricious incursions of irresponsible amateurs, whose industry is often wasted by being misapplied. There ought, nevertheless, to be little difficulty in distributing the observational resources available as advantageously as possible by the intervention of some recognized authority, a central repository being at the same time constituted whence computers could obtain on demand the materials needed for the investigation of particular systems. The tasks of stellar astronomy are so multitudinous as imperatively to demand combination for their effectual treatment.

Discovery, meanwhile, must advance as it can. It is far from desirable that it should remain stationary. Although our acquaintance among double stars is already embarrassingly large, we cannot refuse to extend it. Every addition to it, indeed, is, for a variety of reasons, to be welcomed.

Information on the general subject of stellar compositeness can only be gained by continually widening the area of research. The comparative frequency of its occurrence can thus only be estimated. Struve found one in forty of 120,000 stars examined by him down to 1827 to be compound; but the proportion was naturally higher for the brighter stars, as being in general much nearer the earth, and consequently of more facile optical separation. Every twenty-fifth star in Piazzi's Catalogue, every eleventh in Flamsteed's, proved accordingly to have a companion within less than 32″. But the process of dividing stars has since made such strides as to show that the real preponderance of single over double ones must be much smaller than these numbers indicate. Perhaps, indeed, no star can be called absolutely single. Between a small companion sun and a large planet in its self-luminous stage it is not easy to establish a distinction. The star we know best may not always have been, in its "surpassing glory," so undeniably solitary as it now is. Jupiter, if it ever shone with anything like stellar lustre, would have constituted with it a fine unequal pair such as are plentifully exemplified in our catalogues.

The distribution of double stars is characterized by a somewhat irregular condensation towards the Milky Way. They abound in Cygnus and Lyra, are scanty in Cassiopeia and Cepheus; while Struve met with rich regions where lucid stars are few, in Auriga, Telescopium, and Lynx. Burnham, however, could detect no marked local preferences among his numerous pairs. Sir John Herschel was struck with the paucity of close doubles in the southern hemisphere; but no searching scrutiny has yet been carried out there with modern instruments.

The curious tendency of stars already in close association to split up still further when sufficiently powerful means are brought to bear upon them, has been strongly accentuated by Mr. Burnham's investigations. Primaries with double satellites, such as Rigel, or satellites with double primaries, such as ξ and β Scorpii, swarm on his lists. A fresh instance of the former kind is ζ Piscium (Σ 100), registered by Struve as somewhat widely double, but found to be triple last autumn with the Lick twelve-inch achromatic. The satellite of Struve's companion, at an interval of less than one second from it, is of the eleventh magnitude. The bright stars are estimated by Burnham as of sixth and eighth, but were photometrically determined at Harvard as of 5·4 and 6·4 magnitudes; and Webb thought that the chief of the pair occasionally rose to the fourth rank of lustre. A presumption is thus afforded that both fluctuate in light. Their spectrum, like that of most variable double stars, is of the Sirian type; and their real fellowship is made manifest by a community of proper motion. We have here, then, a genuine ternary system.

Aldebaran is the centre of a mixed group. A small star at 30″ detected by Mr. Burnham at Chicago on October 31, 1877, was described by him as making with the ruddy bright star, a pair resembling Mars and his outer satellite (*Astr. Nach.*, No. 2189). A drift together through space

is probable, Mr. Burnham's remeasurements after eleven years indicating relative fixity, notwithstanding Aldebaran's appreciable advance in the meantime. A more remote companion, however, discovered by Herschel in 1781, is certainly optical, and has been shown at Lick to be double (*ibid.*, No. 2875). Most likely it forms part of the cluster of the Hyades, upon which Aldebaran is casually projected.

The division of the leading member of the group known as σ Orionis illustrates Struve's remark that multiple stars are intermediate between double stars and clusters. Herschel saw it as doubly triple, one set being much fainter than the other. Each proved, under Struve's and Barlow's scrutiny, quadruple, with two very small stars between; while the chief of the decuple assemblage has been resolved at Lick into an excessively close pair, recalling the case of Sir J. Herschel's quintuple star 45 Leporis, broken up into *nine* components by Burnham in 1874. No relative, and scarcely any absolute motion is perceptible among the constituents of σ Orionis; but one of them, called "ashen" by Struve, "grape-red" by Webb, is perhaps variable in colour.

The "Pointer" next the Pole, α Ursæ Majoris, has so far been seen as double only with the giant telescope of Mount Hamilton. The extreme difficulty of the pair arises from the disparity of light between its members, the eleventh magnitude satellite at 0″·83 being almost swallowed up in the glare of its brilliant primary. This disparity, too, throws some shadow of doubt on the reality of the connection, since the supply of small stars for the occupation of chance positions is of course vastly greater than of large. The similar, but more distant companion of γ Cassiopeiæ (at 2″·18) also recently discovered at Lick, is hence not unlikely to prove merely optical, the Milky Way, in which this pair occurs, being pre-eminently rich in such objects; and the presumption is still smaller that a fourteenth magnitude neighbour of θ Cygni owns a genuine allegiance. But here, as Mr. Burnham points out, the proper motion of the larger star will speedily decide (*Astr. Nach*, No. 2912.) There can, on the other hand, be no hesitation in admitting that η Ophiuchi, resolved last spring by the same indefatigable observer into two nearly equal components, at 0″·35, constitutes a physical system, and one in which rapid movements may be looked for. The stars evidently travel together, else they should have been, through the effects of a proper motion of one second of arc in ten years, so far apart a little time back that they could not possibly have escaped separate discernment. Their relation to the Milky Way is picturesque, and has been thought to be significant. "Situated at the extreme northern and pointed extremity of a luminous elongated patch of milky light," Mr. Gore remarks, η Ophiuchi "looks as if it were drawing the nebulous matter after it like the tail of a comet" (*Journal Liverpool Astr. Society*, vol. vii. p. 178). But we may safely regard the appearance as illusory.

Some of Mr. Burnham's measures of known doubles also supply results of interest. Thus, the duplex, sea-green companion of γ Andromedæ can now barely be "elongated" with a magnifying power of 2700 on the great refractor. Yet, so lately as 1881, the two stars could be distinguished with eight inches of aperture. The unequal pair, 99 Herculis, discovered by Alvan Clark in 1859, is even more recalcitrant. No amount of optical constraint can now extract from it the slightest indication of duplicity. Since 1878, 85 Pegasi has traversed 213° of its orbit; and Mr. Schaeberle's new elements, embodying the Lick data, give it a period of 22⅓ years, and oblige us (on the dubious assumption that Brünnow's small parallax can be depended upon) to ascribe a mass to the system eleven times the solar, the components revolving at nearly eighteen times the distance of the earth from the sun. The sun and Jupiter, if of equal *areal* lustre, would present, at half the supposed distance of 85 Pegasi, just its telescopic aspect.

Like 85 Pegasi, δ Equulei is optically triple, while physically double, the companionship of Struve's more distant attendant being in each case temporary and accidental. The bright star of δ Equulei was divided by O. Struve in 1852, and the pair soon proved to be in exceptionally rapid motion. They constitute, in fact, the swiftest binary system yet known. Glasenapp's period, nevertheless, of 11½ years is evidently too short. The Lick measures show the star to be lagging slightly behind its predicted place.

The investigation of stellar orbits has scarcely yet emerged from a tentative stage. Its results are for the most part loose approximations, largely open to future correction. There are very few stars of which the period is known within a few years; there are perhaps two—42 Comæ and ξ Ursæ—of which it is known within a few months. This is due to no lack of skill or diligence in the computers, but solely to the deficiencies, both in quality and quantity, of the materials at their command. Very small errors become enormous when they affect the relative situations of objects divided by a mere *hair-breadth* of sky; and there is no branch of astronomy in which "personality" has played a more conspicuous or a more vexatious part than in double-star measurements. This at least is abolished by photography; which has, however, as yet proved applicable only to a limited class of coupled stars. With the extension of its powers to all, a new era in the knowledge of stellar revolutions may be expected to open.

A. M. CLERKE.

GEOLOGICAL EXCURSION TO THE ACTIVE AND EXTINCT VOLCANOES OF SOUTHERN ITALY.

THE excursion of geologists to the volcanic regions of South Italy came to a very satisfactory conclusion. We have already referred to the first part of the excursion to the Lipari Islands, and the interesting state of activity in which the volcanoes of Vulcano and Stromboli were found to be in. On leaving those islands the party proceeded to examine the Val di Bove, the Cyclopean Islands, the slopes of Etna with its numerous parasitic cones and lava streams, and the central crater itself. The Italian Minister of Public Instruction allowed the party to sleep in the observatory near the mountain summit, and although the weather was rough and misty, about half the party were able to get a good view of the crater, which is now in a solfataric condition. The geologists had also the advantage of becoming acquainted with the mud volcanoes of Paterno. In this part of the excursion the party had the valuble help of Prof. O. Silvestri, to whom Dr. Johnston-Lavis handed over the direction at Etna, although still acting as general director and interpreting Prof. Silvestri's demonstrations. All along the journey the party were *fêted* by the prefect of the province and the mayors of the different communes, and found invaluable hospitality in the splendid villa of the Marquis Favara at Biancavilla. The second fortnight of the excursion was spent at Naples and its vicinity, under the direction of Dr. Johnston-Lavis, aided for the sedimentary rocks by Prof. Bassani of the University of Naples. Although the weather was not so favourable as in Sicily, the delay only amounted to two days. Many thanks are due to the mayor of Naples for his hospitality in providing for the party a splendid steam yacht for their visit to Capri and Ischia, so affording very greatly increased facilities for their excursions. The members gave a day to the examination of the reservoirs and other works connected with the new and most perfect and purest town water supply in Europe, as well as the new drainage works and destruction of the old town of Naples. Although the visit to the crater of Vesuvius had to be delayed for upwards of ten days for suitable weather,

the party had the good fortune to see the volcano in great perfection. There existed at the time of the visit four concentric crater rings and two main vents ejecting red-hot lava cakes, which the geologists were able to approach within ten yards, after which they descended some distance on the slopes of the great cone to a small lava stream issuing from its sides, at which various experiments were performed. The director, who has visited the crater over sixty times, remarked that he had never but once seen it to greater perfection.

The numerous volcanoes of the Phlegrean fields were examined, and most of those present expressed their satisfaction at the many important lessons to be learnt from them. At Pompeii the members had the valuable direction of Dr. A. Sambon for the archæological part, whilst Dr. Johnston-Lavis devoted himself only to explaining the phenomena and materials associated with the destruction of the buried cities.

After Naples the party examined on their way northwards the volcano of Roccamonfina, under the direction of Dr. Johnston-Lavis, and Monte Cassino under that of Prof. Bassani of Naples. The Lyceum at Sessa Aurunca was kindly lent by the commune to accommodate the members during their night's stay on their way over the mountain, a sumptuous dinner being provided by the municipality. The carriages the next day were offered by the province of Terra di Lavoro, and after the ascent had been made of the central cone (Mount Santa Croce) a lunch not less sumptuous than the dinner of the preceding evening was given by the town of Roccamonfina.

The next day was devoted to Monte Cassino, its manuscript and art treasures, as well as the Cretaceous limestones constituting the mountain upon which it is built. Prof. Bassani acted as geological director.

At Rome the party examined the concentric craters, parasitic cones, crater lakes, lava streams of the Alban volcano, also the fossiliferous Pliocene beds capped by volcanic deposits close to the Eternal City. The lower Mesozoic limestones, the travertine, the sulphur springs, and all the other points of geological interest of the Campagna Romana were visited.

As directors of the excursions around Rome may be mentioned Profs. Mele, Portis, and Strüver. Signor Zezi (secretary of the Italian Geological Survey), Signors Demarchi, Clerici, Tellini, and Prof. Lanciani kindly undertook the archæological demonstrations which acted as dessert to the rich geological repast.

The official excursions terminated on October 28, with the trip to Tivoli, although a number of geologists remained to visit the sights of Rome. In the evening a dinner was offered to Dr. Johnston-Lavis, Mr. L. Sambon, and the Roman directors. The thanks of the party were offered to the Minister of Public Instruction, Prefects and Mayors, and private individuals, who had done so much to facilitate the progress, through often almost inaccessible districts, for a large party.

Special votes of thanks were proposed to the different Italian geologists who had kindly offered their services in directing the party through their districts, and lastly to Dr. Johnston-Lavis for originating this new departure in scientific excursions, as well as acting not only as director in his own districts, but interpreting and organizing during the whole excursion, and to Mr. L. Sambon for his administrative skill, his attainments in different branches of science, which added so much to the success and comfort of over forty English geologists, not to speak of the numerous Italians who from time to time joined.

REMARKABLE HAILSTONES.

ON p. 43 of the present volume of NATURE the following extract is given from a paper by Prof. Houston in the Journal of the Franklin Institute :—"On some of the hailstones, though not on the majority of them, well-marked crystals of clear transparent ice projected from their outer surfaces for distances ranging from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch. These crystals, as well as I could observe from

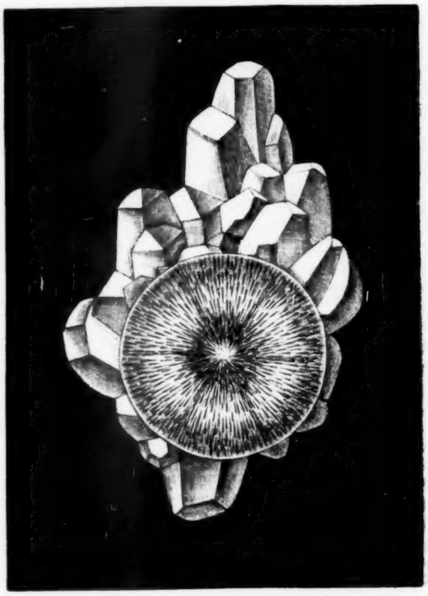

FIG. 1.

FIG. 2.

the evanescent nature of the material, were hexagonal prisms with clearly cut terminal facets. They resembled the projecting crystals that form so common a lining in

geodic masses, in which they have formed by gradual crystallization from the mother-liquor. They differed, however, of course, in being on the outer surface of the spherules."

It is evident from Prof. Houston's paper that this peculiar form of hail was unknown to him, and, as it must also have been unknown to many who have propounded theories as to the formation of hail which will not account for it, I think that a service may be rendered to meteorology by the reproduction of three of the exquisite lithographs of this form of hail given in Prof. Abich's paper, "Ueber krystallinischen Hagel im Thrialethischen gebirge," published at Tiflis in 1871. The hailstones represented in Figs. 1–3 all fell on June 9 (21), 1867, at Bjeloi Kliutsch, a village about twenty miles south-west of Tiflis,

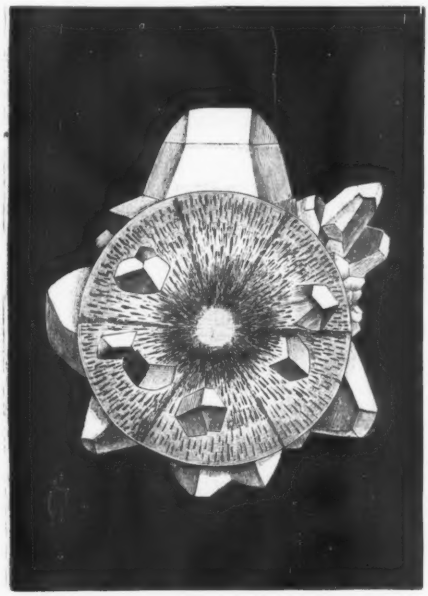

FIG. 3.

and 12,425 feet above sea-level (lat. 41° 33′ N., long. 44° 30′ E.).

Theories of the formation of hail are almost innumerable. I was reading a pamphlet not long since which contained summaries of, I think, twenty-three theories. Some—like Prof. Schwedoff's, that hailstones come from interplanetary space (Brit. Ass. Report, Southampton, 1882, p. 458)—are very droll; but the subject is a very difficult one, and one upon which I do not know of a single good treatise in our language. Possibly, the reproduction of these figures may induce someone to prepare an exhaustive memoir. I could place a large amount of historical and theoretical material at the disposal of any competent person who would undertake the preparation of such a work, it being quite impossible for me to do it myself.

G. J. SYMONS.

NOTES.

AT a largely attended meeting in Edinburgh on Tuesday, Dec. 3, Sir Douglas Maclagan in the chair, it was resolved that Mr. Geo. Reid, R.S.A., should be commissioned to paint a portrait of Prof. P. G. Tait, to be placed permanently in the rooms of the Royal Society of Edinburgh. A committee was appointed to carry out the resolution, including, among others, Mr. John Murray (*Challenger* Expedition), Convener; Mr. Gillies Smith, Hon. Treasurer; Lord President Inglis, Lord Kingsburgh, Lord Maclaren, Sir William Thomson, Sir Arthur Mitchell, Prof. Robertson Smith, Prof. Chiene, Dr. Alexander Buchan, Mr. Robert Cox, and Mr. William Peddie. It was proposed that an etched engraving of the portrait be prepared for distribution among the subscribers, the plate to be destroyed after the required number of copies have been thrown off. It was further resolved that all the Fellows of the Royal Society of Edinburgh, the Professor's old pupils, and others, be afforded an opportunity of taking part in this public recognitition of Prof. Tait's eminent services to science.

ITALY, France, and the United States of America were represented in the elections to foreign membership of the Royal Society on Thursday last. Prof. Stanislao Cannizzaro, of Rome, was elected on the ground of his researches on molecular and atomic weights; Prof. Chauveau, of Paris, for his researches on the mechanism of the circulation, animal heat, nutrition, and the pathology of infectious diseases; and Prof. Rowland, of Baltimore, for his determination in absolute measure of the magnetic susceptibilities of iron, nickel, and cobalt; for his accurate measurements of fundamental physical constants; for the experimental proof of the electro-magnetic effect of electric convection; for the theory and construction of curved diffraction-gratings of very great dispersive power; and for the effectual aid which he has given to the progress of physics in America and other countries.

ADMIRAL MOUCHEZ and MM. Janssen and Perrotin, head astronomers of the Observatories of Paris, Meudon, and Nice, were raised, in November, to the grade of Officer of the Order of the Rose of Brazil, and MM. Frassenet, Paul, and Prosper Henry, admitted to knighthood in the same order. The Paris Correspondent of the *Daily News* says that the diplomas securing to them these distinctions were the last official documents signed by Dom Pedro. He asked his secretary to add a personal compliment to each of the astronomers with whom he was personally acquainted.

SOME time ago we announced that a Physical Society was about to be formed in Liverpool. This has now been done, and we are glad to learn that the new Society begins its career under most favourable conditions. The meeting at which it was constituted was well attended, and displayed much interest in the scheme. Nearly ninety names were at once handed in to the secretary, Mr. T. Tarleton, for membership. Prof. Oliver Lodge, F.R.S., was appointed President. The next meeting will be held in the Physics Theatre, University College, Liverpool, on Monday, the 16th inst., at 8 o'clock, when the President will deliver his inaugural address.

DR. JOHN G. MCKENDRICK, F.R.S., Professor of Physiology in the University of Glasgow, has been elected President of the Philosophical Society of Glasgow.

PROF. LESQUEREUX, the eminent American bryologist and palæontologist, died in his house at Columbus, Ohio, on October 25, at the age of nearly eighty-nine years.

WE regret to learn from a memoir that has been sent to us by Prof. Barboza du Bocage, that Señor José Augusto de Souza died recently at Lisbon, where he was Curator of the Zoological Department in the Museum. He was the author of some useful memoirs on African birds, and is best known for his Catalogue of the *Accipitres*, *Columbæ*, and *Gallinæ* in the Lisbon Museum.

THE fifth of the series of "One Man" Photographic Exhibitions at the Camera Club will be open for private and press

view on Monday, December 16, at 8 p.m., and on and after Tuesday, December 17, it will be open to visitors on presentation of card. The Exhibition will consist of pictures by the late Mr. O. G. Rejlander, and a selection from over 200 of his famous figure and *genre* studies will be shown. The pictures will be on view for about six weeks.

ON November 21 the American Philosophical Society, Philadelphia, celebrated the hundredth anniversary of its first occupation of its present hall. The banquet was a great success. The following were the toasts:—"The language of Science and Philosophy is universal, but adopts various dialectic forms to diffuse knowledge," proposed by Prof. John W. Mallet, representative from the Royal Society of London; "Our kindred Societies in every clime," proposed by Prof. Joseph Lovering, President of the American Academy of Arts and Sciences; "All research into the Book of Nature has not discovered an erratum," proposed by Sir Daniel Wilson, President of the University of Toronto; "The successful pursuit of Science expunges error—it never antagonizes truth," proposed by the Hon. Lyon G. Tyler, President of William and Mary College; "Mental Analysis is the efficient solvent of many difficulties in Science and Philosophy," proposed by the Rev. Dr. Charles W. Shields, Princeton College; and "The labours and achievements of great teachers in Science and Philosophy live after them—these are their monuments," proposed by the Right Rev. Dr. John J. Keane, President of the Catholic University of America.

DR. PAX, of Breslau, has been appointed Curator of the Botanic Garden in Berlin; Mr. D. G. Fairchild, Assistant in the section of Vegetable Pathology in the United States Department of Agriculture; Dr. H. Dingler, Professor of Botany in the Forest Academy of Aschaffenburg; Dr. F. Noll, Professor of Botany in the University of Bonn; and Dr. N. Wille, of Stockholm, Lecturer on Botany at the Royal Agricultural Institution at Aas, near Christiania.

PROF. BORNMÜLLER, Director of the Botanic Garden at Belgrade, has started on a twelve months' botanical tour through Asia Minor. Beginning at Amasia, he will travel through the country between the courses of the Kisil-Irmak and Euphrates, southward to the completely unexplored mountains of Ak-dagh. The *Botanical Gazette* says that this country has only once been explored, thirty-five years ago, by the Russian botanist Wiedemann. According to the same authority, Prof. Bornmüller is a young and very successful explorer, with a great deal of experience, especially from his long journey in 1886, through Dalmatia, Monte Negro, Greece, Turkey, East Bulgaria, and Asia Minor. His original collection will be transferred to Weimar, where it will be carefully gone through by Prof. Hausknecht.

THE "mountain laurel," or *Kalmia*, and the Indian corn, are suggested in American papers as national flowers for the United States.

IN the December number of the *Kew Bulletin* Mr. Thiselton Dyer explains that for some years, when it has been necessary to find space in the Palm House at Kew for the development of new and interesting species of palms, he has not hesitated to transfer to the Temperate House plants which he thought would probably endure a lower temperature. The experiment has been most successful, many of the plants luxuriating in the change. Anxious to obtain further information as to cool cultivation of tropical and sub-tropical plants, Mr. Dyer lately applied for leave to send Mr. Watson, assistant curator at Kew, to the south of France to report on what he might be able to observe. Permission was given; and Mr. Dyer's statement is followed by a series of valuable and interesting notes in which Mr. Watson sums up the results of his mission. His journey took place in the latter part of October. He had a fortnight at his disposal, and during that time he visited as many gardens as possible between Hyères and Mentone. One of the most interesting of the gardens visited was a branch establishment, at Hyères, of the Société d'Acclimatation, Paris. Here a good deal of experimental gardening is practised, plants of all kinds being planted and tested as to their hardiness, &c. Mr. Watson says that while he was inspecting these gardens the idea was suggested "that a well-managed botanical station, devoted chiefly to experimental testing, proving, and breeding operations amongst plants, would, if established in some such favoured locality as Hyères, be capable of much valuable work."

THE following are the lecture arrangements at the Royal Institution, so far as they relate to science, before Easter:—Prof. A. W. Rücker, six Christmas lectures to juveniles on electricity; Prof. G. J. Romanes, ten lectures on the post-Darwinian period; Mr. Frederick Niecks, four lectures on the early developments of the forms of instrumental music (with musical illustrations); Prof. Flower, three lectures on the natural history of the horse and of its extinct and existing allies; the Right Hon. Lord Rayleigh, seven lectures on electricity and magnetism. The Friday evening meetings will begin on January 24, when a discourse will be given by Prof. Dewar on the scientific work of Joule. Succeeding discourses will probably be given by Sir Frederick Abel, Mr. Henry B. Wheatley, Prof. J. A. Fleming, Mr. Shelford Bidwell, Prof. C. Hubert H. Parry, Mr. Francis Gotch, Prof. T. E. Thorpe, Prof. G. F. Fitzgerald, the Right Hon. Lord Rayleigh, and other gentlemen.

MESSRS. MACMILLAN AND CO. will shortly publish the first part of Prof. Eimer's work on "Organic Evolution as the Result of the Inheritance of Acquired Characters according to the Laws of Organic Growth," translated by J. T. Cunningham, M.A., F.R.S.E., late Fellow of University College, Oxford.

MESSRS. BLACKWOOD AND SONS have just published "The Construction of the Wonderful Canon of Logarithms," a translation of "Mirifici Logarithmorum Canonis Constructio," by John Napier, of Merchiston. The work was published in 1619, but is so rare as to be very little known, being only once reprinted in 1620, and never translated. The present translation is by William Rae Macdonald, who also contributes notes and a catalogue of Napier's works.

SLIGHT shocks of earthquake, lasting from five to ten seconds, were felt on Sunday, at Taranto, Foggia, Chieti, Montesaraceno, Agnone, Ancona, and Urbino. At Torremileto, in the province of Foggia, a strong shock is said to have been felt; and a slight shock, followed by a somewhat stronger one, occurred at Naples soon after 6 a.m. On Monday there were seismic disturbances in Dalmatia, Bosnia, and Herzegovina. According to a telegram, through Reuter's Agency, from Vienna, a somewhat severe shock was felt on Monday, at 6.30 a.m., at Knin, Dernis, Sebenico, Trau, Scardona, and Spalato, the direction of the movement being from north-east to south-west. A violent shock, lasting five seconds, occurred at 6.40 at Serajevo, being felt three minutes later at Novi and Krupa also.

AT the ordinary meeting of the Council of the Sanitary Assurance Association, on Monday last, arrangements were completed for a series of lectures during January and February 1890, in the theatre of the College of State Medicine, Great Russell Street. The series will include the following:—Mr. H. Rutherfurd, barrister-at-law, on "House Sanitation from a Householder's Point of View," Sir Joseph Fayrer, F.R.S., in the chair; Prof. T. Roger Smith, on "Household Warming and Ventilation," Sir Douglas Galton, F.R.S., in the chair; Mr. Mark H. Judge, on "The Sanitary Registration of Buildings Bill," Lord Henry Bruce, M.P., in the chair. The object of

the Association being to promote good sanitary arrangements in the houses of all classes of the community, both men and women are invited to these lectures. Discussion is invited.

THE "Fauna of British India," of which we noticed the first volume of fishes last week, is making steady progress. Mr. Eugene Oates will produce the first volume of the birds of India during the present month. The work will be principally founded on the great Hume Collection in the British Museum, and the author of the "Hand-book of the Birds of British Burmah," may be trusted to give a thoroughly good account of the birds of India. Side by side with his three volumes on Indian ornithology, Mr. Oates will also publish a new edition of Mr. A. O. Hume's "Nests and Eggs of Indian Birds," which has long been out of print. For this purpose Mr. Hume has intrusted to Mr. Oates the whole of the material collected by him for a second edition, and there is no doubt that the work will be warmly welcomed by naturalists. Portraits of some of the leading men who have contributed to the history of Indian ornithology will be given in this new edition, and will form an interesting feature of the work.

MR. FRANCIS NICHOLSON, a well-known Manchester ornithologist, is about to issue an English translation of Sunderall's "Tentamen," with a memoir and portrait. This work will be welcome at the present time, when increased attention is being paid to the classification of birds.

MR. SEEBOHM will, we understand, propound his system of arrangement of the class Aves in the January number of the *Ibis*, and the memoir will doubtless be a valuable one, as the author is known to have devoted close study to the subject during the past two years.

MR. A. P. GOODWIN, who was with Sir William McGregor on his recent exploration of Mount Owen Stanley, is about to start on a lecturing tour in America. He was successful in taking several interesting photographs of the country visited by the Expedition, and he paid especial attention to the habits of the Birds of Paradise and the Bower-birds. He has some remarkable sketches of the playing-grounds of some of the latter, notably of *Amblyornis subalaris*, of Sharpe, which rivals in decorative faculty the Gardener Bower-bird (*Amblyornis inornata*) of North-Western New Guinea.

PROF. GIARD has recently discovered a micro-organism which possesses the power of conferring luminosity or phosphorescence upon different crustaceans. This microbe was found in the tissues of *Talitrus*, and is easily cultivated in appropriate media. It soon kills *Talitrus*.

M. LOUBAT, member of the New York Historical Society, has presented the French Academy of Inscriptions with a sum producing 1000 francs per annum; his intention being that a prize of 3000 francs shall be offered every three years for the best printed work concerning the history, geography, archæology, ethnography, linguistics, and numismatics of North America. The first prize will be granted in 1892, and the Academy has decided that the works submitted for consideration shall not relate to matters referring to an earlier date than 1776. The competition will be open to the author of any work on the subject published after July 1, 1889, in any of the following languages: Latin, French, English, Spanish, and Italian. Two copies must be sent to the Secretary of the French Institute before December 31, 1891.

IN the Pacific Coast region there are now four flourishing colonies of introduced pheasants. Dr. C. Hart Meriam, who refers to the subject in his last Report to the American Agricultural Department, says that the most northerly of these colonies is at the south end of Vancouver Island, near Victoria; the second in Protection Island, in Puget Sound; the third at the junction of the Willamette River with the Columbia; and the fourth in the middle portion of the Willamette Valley. The two latter colonies are now separated by so narrow a strip of territory that they will doubtless become united during the next few years. All the pheasants of the three colonies last mentioned appear to have been imported from China by Judge O. N. Denny.

THE American Agricultural Department has been making careful inquiry as to the food of crows; and the result, as set forth in a Report by Mr. Walter B. Barrows, is likely to surprise those who have always contended that these birds do very much more good than harm. It is not disputed that they destroy injurious insects, that they are enemies of mice and other rodents, and that they are occasionally valuable as scavengers; but these services are slight in comparison with the mischief for which they are responsible. The injury done by them to Indian corn, wheat, rye, oats, and other cereals is enormous. According to one observer, the crow eats corn "from ten minutes after planting until the blades are three inches high;" and more than a score of other observers testify that he not only pulls up the young plants, but digs up the newly sown seed. His depredations extend to potatoes, sweet potatoes, beans, pea-nuts, cherries, strawberries, raspberries, and blackberries; and he widely distributes certain poisonous plants, the seeds of which are improved rather than impaired by passage through his digestive organs. As if all this were not enough, it is shown that the crow eats beneficial insects, and that he makes himself a most formidable nuisance by destroying the eggs and young both of domesticated fowls and wild birds.

TWO new seismoscopes, made by Brassart Brothers, of Rome, and adopted at the Italian meteorological stations, are described in the *Rivista Scientifico Industriale* of October 15. They are of a very simple nature, the one consisting merely of an iron rod, about 5 inches long, leaning slightly against an adjustable screw support near its middle, and with its lower pointed end in a cup. When a shock or tremor occurs, the rod falls away from its support and is caught by a fixed metallic ring making electric contact and ringing a bell. In the other instrument, the ring is connected with a hinged lever arrangement, which stops the mechanism of a timepiece, showing when the shock occurred.

THE National Association for the Promotion of Technical and Secondary Education has issued an excellent Report on the existing facilities for technical and scientific instruction in England and Wales. As Mr. Acland and Mr. Llewellyn Smith explain in a prefatory note, the Report is not intended so much for experts as for those who wish to obtain, without consulting many Blue-books and other official documents, some trustworthy information as to what is being done. The facts have been arranged with the utmost care, and the work ought to be of considerable service in helping to show "what are the gaps in our educational system that must be filled, and how great is the need for the re-organization and improvement of existing agencies."

THE Annual Report of the Manchester Literary and Philosophical Society, published in vol. ii., 4th series, of the Proceedings, shows a marked improvement in the financial condition of the Society, the membership being only one less than at the corresponding period last year. The volume contains many papers and abstracts of papers of varying interest. There is a long paper on "*Hymenoptera Orientalis*" by Mr. Cameron, giving descriptions of the various species, their habits and localities, and references to the literature of the subject. Dr. A. Hodgkinson communicates an interesting paper on the "Physical Cause of Colour in Natural and Artificial Bodies," recording experiments which tend to show whether the colour is produced by a

structure of thin plates, or one of fine lines. There are two papers on leaves from the cutting of the Ship Canal, one giving a general description, and the other, by Dr. Schunck, F.R.S. showing that the green colouring-matter, which has proved to be so permanent, is due to a modified form of chlorophyll; spectroscopic examination of the colouring-matter showed it to be identical with that produced by the action of dilute hydrochloric acid on ordinary chlorophyll.

THE Middlesex Natural History and Science Society has issued a volume containing its Transactions during the session 1888-89. The volume opens with an interesting Presidential address by Prof. Flower, on the Natural History Museum, Cromwell Road, and some recent additions thereto. Mr. E. M. Nelson has an illustrated paper on diatom structure; and Mr. J. A. Brown contributes a paper, also illustrated, on working sites and inhabited land surfaces of the Palæolithic period in the Thames Valley.

THE fourth volume of "Blackie's Modern Cyclopædia" has been issued. It begins with the word "fire" and ends with "Ilorin." The work, as we have said on former occasions, is admirably edited by Dr. C. Annandale. The articles are necessarily brief; but, so far as we have been able to test them, they are clear and accurate. There is no falling off in the present volume.

MESSRS. WARD, LOCK, AND CO., have added to their "Minerva Library of Famous Books" a reprint of Dr. A. R. Wallace's fascinating "Narrative of Travels on the Amazon and Rio Negro." A biographical sketch of the author is contributed by Mr. G. T. Bettany, the editor of the series; and the volume includes a portrait of Dr. Wallace, a map, and full-page illustrations.

HAZELL'S Annual for 1890—the fifth issue—has been published. It is edited by Mr. E. D. Price. An immense quantity of information, alphabetically arranged, has been packed into this useful volume. Many articles which the editor describes as "new and important" have been inserted in the present issue.

A SCIENCE CLUB has been formed among the students of the University of St. Andrews for the purpose of developing the interest already taken in scientific pursuits. Prof. W. C. McIntosh, F.R.S., has been elected Hon. President for the session 1889-90.

ANOTHER important paper by M. Henri Moissan upon the perfected mode of preparation and upon the density of fluorine, is contributed to the current number of the *Comptes rendus*. Since the appearance of his paper of two years ago, M. Moissan has employed an electrolysis apparatus of much larger size, and has added to it an accessory apparatus by means of which the gas may be obtained quite free from vapour of hydrofluoric acid, which, as described in NATURE last week, is the cause of the destructive action upon platinum. The platinum U-tube of the new apparatus has a capacity of 160 c.c., and contains during the electrolysis 100 c.c. of hydrofluoric acid. The exit tube at the positive side, from which the fluorine is liberated, is continued into a small platinum spiral condenser immersed in a bath of methyl chloride at − 50° C., where all but the last trace of hydrofluoric acid is retained. From this the gas is led through two platinum tubes filled with fragments of sodium fluoride, a salt which combines with hydrofluoric acid with great energy, forming hydrogen sodium fluoride. By these means the fluorine is obtained perfectly pure, and is quite invisible in dry air, no trace of fuming being apparent, as is the case before purification. In order to determine the density of the gas, a couple of ingeniously constructed platinum flasks have been employed. Each of these flasks is closed by a cylindrical stopper also of platinum; to the side of the neck a side tube is attached on a level with the centre of the stopper. Through the stopper an aperture is bored in such a manner that, when the stopper is rotated into a certain position, connection is established between the interior of the flask and the side tube. A vertical tube also passes through the stopper and penetrates to near the bottom of the flask; this tube is also closed at its upper end by means of a platinum stopper. The stoppers are finely polished and adjusted with great care. Each flask weighs about 70 grams and has a capacity of about 100 c.c. In the density determinations the two flasks were counterpoised on the two pans of the balance. One of them was then filled with pure dry nitrogen gas, which was subsequently displaced by the pure fluorine, the electrolysis apparatus being connected with the upper end of the vertical tube of the density flask by means of flexible platinum tubing. The fluorine was allowed to pass through the apparatus for five minutes after cold silicon was readily ignited by the gas issuing from the side exit tube. The stopper of the flask was then rotated through half a revolution, so as to completely shut off the exit tube, and the stopper of the vertical tube replaced. The flask was again weighed against the other flask containing air, and the difference of weight noted. The amount of residual nitrogen was estimated by opening the stopper of the vertical tube under water, when the fluorine instantly decomposed an equivalent of water, liberating oxygen and forming hydrofluoric acid. The mixture of oxygen and the residual nitrogen was then collected, and the oxygen absorbed by pyrogallic acid and potash. Three determinations yielded, for the density of fluorine compared with that of hydrogen, 18·22, 18·26, and 18·33. These values appear to indicate that the number 19, usually taken as representing the atomic weight of fluorine, is slightly too high, and this view is confirmed by the low numbers obtained in former determinations of the density of phosphorus trifluoride.

THE additions to the Zoological Society's Gardens during the past week include a Malayan Bear (*Ursus malayanus* ♀) from Malacca, a Gold Pheasant (*Thaumalea picta* ♀) from China, presented by Captain Bason; a Common Squirrel (*Sciurus vulgaris*), British, presented by Mr. W. Aubrey Chandler; a Mexican Deer (*Cariacus mexicanus* ♂) from Peru, a Grey-breasted Parrakeet (*Bolborhynchus monachus*) from Monte Video, deposited; an American Bison (*Bison americanus* ♂ born in the Gardens.

OUR ASTRONOMICAL COLUMN.

OBJECTS FOR THE SPECTROSCOPE.

Sidereal Time at Greenwich at 10 p.m., December 12 = 3h. 27m. 9s.

Name.	Mag	Colour.	R.A. 1890.	Decl. 1890.
			h. m. s.	° ′
(1) G. C. 768	—	—	3 39 39	+23 14
(2) D.M. + 71° 201 ...	7	Reddish-yellow.	3 18 56	+71 29
(3) ε Eridani	3	Yellow.	3 27 5	− 9 51
(4) ζ Eridani	4	White.	3 10 5	− 9 14
(5) 27*a* Schj.	7	Red-yellow.	3 32 21	+62 18
(6) R Lacertæ	Var.	Orange.	22 38 23	+41 48

Remarks.

(1) The General Catalogue description of this nebula is as follows:—!!! Bright; very large, irregular figure. According to Tempel, this is a variable nebula, and its spectrum, which has not yet been recorded, will therefore have a special interest. Continued observations may, very probably, give a clue to the origin of the variability.

(2) Dunér classes this with stars of Group II., but states that the spectrum is only feebly developed. Further observations are necessary before it can be placed in position on the "tem-

perature curve." As I have previously pointed out, the "feebly developed" stars of the group are probably either early or late species, as the bands would be weak in either case. If it be an early star, the bands in the blue will be most strongly developed; while, if it be a late star of the group, the bands in the red will be strongest. In the latter case, lines would probably also be seen.

(3) Konkoly classes this with stars of the solar type. As in former stars of this class which have appeared in these columns, observations are required to decide whether the star belongs to Group III. or to Group V. (For criteria, see p. 20.)

(4) This is a star of Group IV., of which observations of the relative intensities of the hydrogen and metallic lines are required, so that the star may be arranged in a line of temperature with others.

(5) This is a star of Group VI., which Dunér describes as having a spectrum consisting of three zones, band 2 being probably also present. Particular attention should be given to the intensity of the band 6 as compared with the others. Other subsidiary bands should also be looked for, as they are seen in several stars of lower magnitude, and it is important that we should know whether their presence is dependent solely upon the brightness of the star, or really indicates a difference in the condition of the star itself. (For notation of bands, see p. 112.)

(6) The maximum of this variable will occur on December 27. The period is 315 days, and the magnitude varies from < 13.5 at minimum to 8·6 at maximum. The spectrum has not yet been recorded.

Note.—Some of the comets of which ephemerides have recently appeared in NATURE may possibly be bright enough for spectroscopic examination. It is not likely that, at their present perihelion distances, their temperatures will be very high, so suggestions for comparison spectra may be confined to those suitable for low-temperature comets. The probable sequence of spectra as a comet leaves aphelion is as follows:—(1) The spectrum of a planetary nebula, as in the comets of 1866–67, observed by Dr. Huggins. This consists of a single line in the position of the chief nebula line near λ 500. (2) The low-temperature spectrum of carbon, consisting chiefly of three flutings near λ 483, 519, and 561. (3) The high-temperature spectrum of carbon, consisting mainly of flutings near λ 564, 517, and a group of five flutings extending from 468 to 474. The most convenient comparison to begin with will be the flame of a spirit-lamp, which will give the hot carbon spectrum. If this does not show coincidences with the cometary bands, a comparison with the bright fluting in the spectrum of burning magnesium should be made. This will determine the presence or absence of the chief nebula line. If neither shows coincidences, the positions of the bands relatively to the hot carbon flutings may roughly indicate the presence or absence of cool carbon. As the two less refrangible flutings of cool carbon fall very near to two of hot carbon, the best criterion for cool carbon is the fluting at λ 483, which is about one-third of the distance from the fluting commencing at 474 towards that commencing near 517. Any variation of the form of the least refrangible cometary band from the corresponding carbon fluting should be noted, as this varies with the temperature (see Roy. Soc. Proc., vol. xlv. p. 168). A. FOWLER.

PHOTOMETRIC INTENSITY OF CORONAL LIGHT.—The observations made by Prof. Thorpe during the solar eclipse of 1886 (Phil. Trans., vol. clxxx., p. 363, 1889) show that the diminution in intensity of coronal light at different distances from the sun's limb does not vary according to the law of inverse squares. The following measurements make this apparent:—

Distance in Solar Semi-diameters.		Photometric Intensity. Observed.		Law of Inverse Squares.
1·6	...	0·066	...	0·066
2·0	...	0·053	...	0·042
2·4	...	0·043	...	0·029
2·8	...	0·034	...	0·022
3·2	...	0·026	...	0·016
3·6	...	0·021	...	0·013

The brightness of the brightest measured part of the corona (1·55 solar semi-diameters) was 200 times less bright than that of the surface of the moon, or about 0·06 candle, whilst the furthest spot at 3·66 solar semi-diameters was only 1/800 of the brightness, or 0·015 candle. The results obtained will be useful in comparing the brightness of the corona on this occasion with that of other eclipses, and determining what connection the sun-spot periods have with the coronal phenomena.

CORONA OF JANUARY 1, 1889.—Prof. Tacchini, in the *Atti della R. Accademia dei Lincei* (p. 472), gives a note on the corona as shown in a positive copy, on glass, of one of Mr. Barnard's negatives taken during this eclipse. The corona extends, according to Prof. Tacchini, from $+64°$ to $-68°$ on the west limb of the sun, and from $+53°$ to $-68°$ on the east limb, these being about the limits of the zone of the maximum frequency of protuberances derived from his own observations. Two of the protuberances on the photograph were observed at Rome and at Palermo.

MINOR PLANET (12), VICTORIA.—Dr. Gill has issued the ephemeris of this planet for the opposition of 1889, computed from elements which have been corrected from the observations of 1888.

Observatories co-operating in the meridian observations of Victoria should compare their results with this ephemeris, employing 8"·80 for the solar parallax.

Dr. Auwers has undertaken the discussion of the meridian observations, so the detailed results should be forwarded to him as soon as possible.

COMET SWIFT (*f* 1889, NOVEMBER 17).—The following ephemeris is given by Dr. R. Schorr (*Astr. Nachr.*, No. 2937):—

1889.	R.A. h. m. s.	Decl. ° ′	1889.	R.A. h. m. s.	Decl. ° ′
Dec. 12...	23 47 28 ...	+19 6·7	Dec. 22...	0 19 7 ...	+21 49·4
13...	50 31 ...	19 23·6	23...	22 24 ...	22 4·8
14...	53 36 ...	19 40·4	24...	25 43 ...	22 20·1
15...	56 42 ..	19 57·1	25...	29 2 ...	22 35·2
16...	59 50 ...	20 13·6	26...	32 23 ...	22 50·1
17...	0 2 59 ...	20 29·9	27...	35 44 ...	23 4·8
18...	6 10 ..	20 46·1	28...	39 6 ...	23 19·3
19...	9 22 ...	21 2·2	29...	42 30 ...	23 33·6
20...	12 35 ...	21 18·1	30...	45 54 ...	23 47·7
21...	15 50 ...	21 33·8	31...	49 18 ...	24 1·5

The brightness of the comet = 0·81 (December 12) and 0·57 (December 31), that at discovery being taken as unity.

Comptes rendus, No. 23 (December 2, 1889), contains observations of this comet extending from November 20 to November 27. It is noted that the comet is very feeble and diffuse.

PERIODIC COMETS.—Several short-period comets return to the sun in 1890, and their ephemerides will be furnished as soon as issued. The perihelion passage of Brorsen's comet will occur about February 25, Denning's comet may be expected to return to perihelion in May, and D'Arrest's comet about the third week in September. The orbit of Barnard's comet has not yet been sufficiently defined to enable the date of perihelion passage to be stated.

THE ECLIPSE PARTIES.—The following telegram relating to the eclipse parties has been received:—"*Loanda, December* 7.—The United States corvette *Pensacola*, Captain Arthur R. Yates, with the Solar Eclipse Expedition on board, arrived at St. Paul de Loanda to-day. The voyage down was very smooth, with delightful sailing. The astronomers were at work on the instruments all the way, and are all ready for the eclipse. The time is now so short that it is inadvisable to attempt to take the party and all their instruments inland, so the Expedition will locate at Cape Ledo immediately, and send one or two branch parties inland, with such instruments as are not bulky or heavy, and can quickly be set up and adjusted. The European eclipse observers are beginning to arrive here. Mr. Taylor, of the Royal Astronomical Society, London, has already arrived with a small outfit of apparatus. None of the French or German astronomers are yet here. Cape Ledo turns out to be in every way the most favourable point for locating the American Expedition. Not only are the meteorological conditions likely to be better, but the party can live for the most part on the *Pensacola*, as she will lie at a safe anchorage near the shore. The health of the members of the party is thus insured. The eclipse is several seconds longer there than at Muxima, and chances for clear afternoon skies appear to be rather better. If nothing is heard from the Expedition for the next few days, it may either be taken that the Eclipse Station is finally located at Cape Ledo, or that the semi-cannibal Quissamas have cleared out the whole Expedition."

RECENT INDIAN SURVEYS.

THE "Statement exhibiting the Moral and Material Progress and Condition of India," recently issued, devotes, as usual, a section to the survey work of the past year, of

which the following is a summary. The work of the Survey of India is divided under five heads, namely:—(1) Trigonometrical Survey, (2) Topographical Survey, (3) Cadastral Survey, (4) Special Surveys and Explorations, (5) Map Production.

Trigonometrical.—Out of twenty-six survey parties employed during the year, only one was engaged on trigonometrical work. It carried secondary triangulation for 370 miles along the Coromandel coast as far as the Tanjore District; the work is intended as a basis for marine survey operations. Some triangulation in extension of the great Indian triangles had to be undertaken in Baluchistan as a basis for topographical maps there.

Topographical.—The number of parties engaged in this work was reduced from eight to six, and 15,673 square miles of topographical survey were accomplished, which included 934 square miles of survey in the Southern Mahratta country, the same party doing a quantity of detached forest survey in the valuable teak forests of Kanara; 1085 square miles of topographical work in Guzerat, besides 285 square miles of detailed forest survey in the jungles of Thana and Nasik. Parties 15 and 16 continued the Baluchistan survey, accomplishing in all 11,977 square miles. The cold and snow in winter, as well as the difficulty in getting supplies, were extremely trying to the parties. 977 square miles were surveyed in the Himalayan districts of Kangra, Simla, and the native States pertaining to those districts; 4535 square miles of triangulation and 1284 square miles of topographical survey in the Madura district and the States of Travancore and Cochin of South India. The cost of the Himalayan work and of the Baluchistan surveys was considerably cheaper per square mile than in the previous year.

Forest Surveys.—Two half-parties of the Topographical Survey did fresh work, as above stated, in Bombay. Ground was broken in the forests near Hoskungabad of the Central Provinces; but in the first year, on account of climatic difficulties and the ruggedness of the country, the out-turn of work was small. 343 square miles of forest survey were effected in the forests of the Prome and Thayetmyo districts of Lower Burmah. In Gorakpur of the North-West Provinces, and in Orissa, surveys of certain forest reserves were made by cadastral parties working in the neighbourhood. The whole area of forest surveys accomplished by all these parties during the year was 893 square miles.

Geodetic.—Telegraphic longitude operations were resumed, and seven arcs of longitude were measured between trigonometrical stations in Southern India. The season's observations tend strongly to confirm previous evidence that on the coast of India there is a perceptible deviation of the plum-line towards the ocean.

Tidal and Levelling Operations.—The recording of tidal curves by self-registering tide-gauges, their reduction, and the publication of tide-tables, were continued at eighteen stations, of which seven are permanent, and eleven are temporary for five years. The registrations of tides were satisfactory, and there were few failures. So far as predictions of high water were concerned, 98 per cent. of the entries in the tables were correct within 8 inches of actual heights at open coast stations, and 69 per cent. at riverain stations, while as to time of high water, 56 and 71 per cent. respectively of the entries were correct within fifteen minutes. Levelling operations were prosecuted from Madras to Vizagapatam, at False Point, to connect the Marine Survey beach marks with the main line of level, and from Chinsurah to Nuddea, along the right bank of the Hooghly. There were 597 miles of double levelling accomplished. In Upper Burmah, survey parties or surveyors accompanied the columns which marched through the northern Shan States, the southern Shan States, and the columns that operated in the Yaw country, the Chindwan Valley, and the Mogoung district. Triangulation was carried over 23,274 square miles, and 20,780 square miles of hitherto unknown country were mapped on a scale of four miles to the inch, of which 7605 belonged to the Shan States. North-east from Mandalay, the survey was carried as far as the Kanlow ferry, on the Salween River, a place on the old caravan road between Burmah and China. A large scale map was made of the Ruby Mines tract, showing the sites of all ruby workings. Surveyors accompanied an exploring expedition from the Assam Valley, across the Patkoi ranges, into the Hukong Valley of Upper Burmah, and surveyed two practical passes through the Patkoi hills. A good map of the Black Mountain country was prepared on observations and surveys taken by officers deputed with the Hazara field force. The hill country of Western Nepal has been observed and mapped, and a compilation of recent observations by explorers in Tibet and Bhutan will shortly be published.

Marine Survey.—The survey-vessel *Investigator* and two boat parties were employed on marine surveys throughout the open season, the staff being employed in the chart office during the monsoon months. The *Investigator* accomplished 4630 miles, and the boat parties 1542 miles of soundings. Among the results of the year's work were soundings round the approaches to Madras, whereby it was shown that there were 1700 fathoms of water on a spot hitherto marked on the charts as "5 fathoms doubtful." Surveys were made round the Laccadive and the Andaman Islands, at the Palk Straits, the Western Coral Banks, on the Malabar coast near Cannanore and Tellicherry, and off Parbandar. Interesting marine organisms, some of them quite new, were brought up by the trawler, especially from a depth of 250 fathoms off the Andamans. The observations for temperature have enabled the survey to construct a temperature curve which is fairly constant for all parts of those seas.

Geological Survey.—Among the investigations by the Geological Survey during the year 1888 may be mentioned the examination of the auriferous rocks known as the Dharwar rocks, bands of which occur in the gneiss mountains, from the edge of the Deccan trap in the meridian of Kaladgi, across the upper basins of the Kistna, Tangabhadra, Penner, and Cauvery Rivers. At many places in these bands of Dharwar rock, the geological officers discovered traces of extensive gold workings, the existence of which was hardly known to the present inhabitants. The investigators consider that in many places, especially in the Kolar and Maski bands, gold will be found in quantities that will repay working. The workers of past centuries used to crush the ore in saucer-like hollows in the solid, tough, trappoid rocks, with rounded granite crushers, weighing about a ton each. The supposed diamond sources in the Anantapur district of Madras were examined, but with only negative results. The coal-field of Singareni, in the Nizam's dominions, was examined; it was estimated that 17,000,000 tons of coal were available in the field. The geologists reported that the cost of raising coal into waggons at the pit's mouth ought not eventually to exceed 2 rupees a ton. Further examinations were made of the coal-bearing rocks of Western Chota Nagpore and of Rajmehal; the latter coal source cannot be thoroughly tested until bore holes are put down. The seams of coal at Kohst, in Baluchistan, were found to contain 1½ to 2 feet of good coal at times; coal from surface workings is now chiefly used in locomotives; but the best plan for permanent workings has not yet been settled. The petroleum sources at Khatun, in Baluchistan, and in the Rawal Pindi district of the Punjab, were visited by officers of the Survey; the Khatun oil is too thick to flow down a pipe for forty miles to the railway, where it has made excellent fuel. The Cashmere coal-field, in the upper valley of the Chenab, was also examined.

The report of the Cadastral Surveys and Settlements is devoid of scientific interest.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—In the course of the term which has just come to an end, Mr. J. B. Farmer, B.A., has been elected to a Fellowship at Magdalen, after an examination in botany—a subject to which no Fellowship has been allotted for many years; and the Burdett-Coutts Scholarship in Geology has been awarded to Mr. F. Pullinger, Corpus.

Mr. Hatchett Jackson will continue to act as Deputy Professor of Comparative Anatomy for the next two terms at least.

The recently founded Readership in Geography seems to have proved a success this term, as Mr. Mackinder had a class of fifty in regular attendance.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, November 21.—"On the Tubercles on the Roots of Leguminous Plants, with special reference to the Pea and the Bean." By H. Marshall Ward, M.A., F.R.S., F.L.S., late Fellow of Christ's College, Cambridge, Professor of Botany

in the Forestry School, Royal Indian Engineering College, Cooper's Hill.

In the Philosophical Transactions for 1887 (vol. clxxviii. B, pp. 539–562, Pls. 32 and 33) the author published the results of some investigations into the structure and nature of the tubercular swellings on the roots of *Vicia Faba* and other Leguminous plants.

The chief facts established in that paper were as follows:—That the tubercles occur in all places and at all times on the roots of Papilionaceous plants growing in the open land, but that in sterilized media and in properly conducted water-cultures they are not developed, unless the root is previously infected by contact with the contents of other tubercles. In other words, the tubercles can be produced at will by artificial infection. The author also showed that the act of infection is a perfectly definite one, and is due to the entrance into the root-hair of a hypha-like infecting tube or filament, which starts from a mere brilliant dot at the side or apex of the root-hair, passes down the cavity of the latter, traverses the cortex of the root from cell to cell, until its tip reaches the innermost cells of the cortex, where it branches and stimulates these cells to divide and form the young tubercle.

These facts of the infection were entirely new, as were the methods, and the author showed actual preparations of the infecting filaments passing down the root-hairs, at the time (June 1887).

In this paper the author described and explained the trumpet-shaped enlargements of the filaments, and the bacterium-like contents of the cells (bacteroids—gemmules), and showed that the latter arise from the former. He also pointed out that the root-hairs are distorted at the point of infection, and that the infecting filament originates there from a brilliant granule, presumably one of the bacteroids. Another important observation was that the protoplasm of the cells of the tubercle is stimulated by the activity of the bacteroids in it, and behaves like a plasmodium.

The author now draws attention to some results of his further researches into this confessedly difficult subject.

After numerous culture experiments and observations made last year (1888), it was decided to abandon the broad-bean as the subject for histological analysis, chiefly because it takes so long to exhaust its stores of reserve materials; it was better for the cultures to be made with the pea, the cotyledons of which are so much smaller, and the plant of which is more easily managed in every way in water and pot cultures, while the tubercles and their contents present no essential features of difference.

But more conclusive evidence than the above is offered for the identity of the bacteroids in the two cases. In some of the cultures made in the summer of 1888 the roots of the pea were successfully infected with bacteroids taken from the tubercles of the bean, and this is a point of importance, in view of the belief that each species of Leguminosæ may have its own species of bacteroid.

It is especially the very young root-hairs, with extremely delicate cell-walls, that are infected, and the first sign is the appearance of a very brilliant colourless spot *in* the substance of the cell-wall: sometimes it is common to two cell-walls of root-hairs in contact, and not unfrequently one finds several root-hairs all fastened together at the common point of infection. This highly refringent spot is obviously the "bright spot" referred to in the author's previous paper as the point of infection from which the infecting filament takes origin. It soon grows larger, and develops a long tubular process, which grows down inside the root-hair, and invades the cortex, passing across from cell to cell, as described in 1887.

As a matter of fact, then, the "bright spot" is the point of origin of the infecting filament; and, as a matter of inference from the experiments, it cannot but be developed from one of the "bacteroids" or "gemmules" of the tubercles. This attaches itself to the root-hair, fuses with and pierces the delicate cellulose wall, and grows out into a hypha-like filament at the expense of the cell contents. The further progress of this filament has already been described in the author's memoir in the Philosophical Transactions for 1887.

Researches were made during 1888 and 1889 with the object of learning more about the conditions which rule the development of the tubercles, and the relations of the organism to them. The experiments seem to prove conclusively that the well being of the organism of the tubercle and that of the pea or bean go hand in hand. This of course is only so much evidence in favour of the view that we have here a case of symbiosis of the closest kind, as expressed in the previous memoir.

During the spring and summer of 1888 numerous experiments were made with water-cultures with beans, allowed to germinate in soil so as to be infected by the "germs" therein, as demonstrated previously. Several dozens of such cultures were made, and some of them placed in the dark, others in the ordinary light of the laboratory, and some in a well-lighted greenhouse. Tables were prepared showing the number of leaves, living and dead, the condition of the roots, the height of the stem, and so forth, as recorded every week or so (or at shorter intervals) when the plants were examined. It resulted that, when the beans are in any way so interfered with that they do not assimilate more material than is necessary for the growth and immediate requirements of the plant, the infecting organism either gains no hold at all on the roots, or it forms only small tubercles which are found to be very poor in "bacteroids": in some cases the starving plants began to develop tubercles, which never became large, and in which the infecting organism seemed to be in abeyance. Whether this is due to the bacteroids being developed in small quantities, or to their absorption into the plant, is still a question.

In these tubercles the chief difference was the paucity in bacteroids, and the prominence of the branched filaments in the cells.

In the spring of this year (1889) the author started a series of water-cultures of beans, infected artificially by placing the contents of tubercles on their root-hairs, and kept the roots oxygenated by passing a stream of air through the culture liquid for twenty-four hours at intervals of a few days: here again the increased growth of the plants—not compensated by increased assimilation—seemed to cause the suppression of the tubercles, or the formation of very poor ones only. These and similar experiments lead to the conclusion that the organism which induces the development of the tubercles is so closely adapted to its conditions that comparatively slight disturbances of the conditions of symbiosis affect its well-being: it is so dependent on the roots of the Leguminosæ, that anything which affects their well-being affects it also.

Some experiments with peas, which are now being tabulated, may throw some light on the wider question which has been raised of late, as to the alleged connection between the development of these tubercles and the increase of nitrogen in Leguminous plants. Thirty-two peas were sown in separate pots of silver-sand, or soil, in five batches of six each, and one of two, and treated in various ways.

The tubercles were developed on all but one of the plants, except those in the completely sterilized media. The evidence at present goes to show that *the Leguminous plant gains nitrogen by absorbing the nitrogenous substance of the bacteroids from the tubercles;* that nitrogenous substances are thus brought by the "bacteroids" ("gemmules") of the infecting organism of the plant; and that, finally, no satisfactory explanation seems forthcoming as to how the organism obtains this nitrogen in certain cases where no compounds of nitrogen have been added. At any rate, if we regard the pot of sand and its pea as one system, there is in some cases *a distinct gain of nitrogen in the crop, and in the sand at its roots.*

The author then refers to the literature since 1887, and reviews two papers by Prażmowski which bear directly on these researches.

"To sum up, Prażmowski's account of the whole matter confirms that given to the Royal Society by the author in 1887, excepting that he interprets the origin and nature of the bacteroids differently; he regards them as produced from the *contents* of the filaments—as germ-like bodies developed in the interior of the filaments, and not budded off from them. This is hypothesis only, however, for the author expressly states (p. 253), 'Direct habe ich ihre Theilungen nicht gesehen, obgleich ich mir die Mühe gab, sie in den verschiedensten Nährmedien und unter den verschiedensten äusseren Bedingungen zu züchten.' He concludes they can only multiply in the still *living* protoplasm.

"As to the shapes of the bacteroids and tubercles, Prażmowski's statements agree with those of previous observers, and he also remarks the plasmodium-like appearance of the cell protoplasm at certain stages, as noticed by myself. Some observations on a possible spore-formation need not be dwelt upon, as he recognized his mistake in a subsequent paper in 1889.

"He leaves the question as to the origin of the bacteroids by budding or otherwise quite undecided, having failed to satisfy himself whether my suggestion is right or not; at the same time, he fully agrees with me and others in believing that these tiny bodies must be the infecting agents, easily and abundantly distributed as they are in the soil, water, &c."

The author concludes by saying:—

"I think it will be admitted by all who study the literature of this subject, that the only real point at issue between Prażmowski and myself is the nature of the bacteroids and their origin from the filaments. I interpreted them as extremely minute budding 'gemmules,' and not bacteria; Prażmowski, with Beyerinck, regards them as true Schizomycetes. We have all alike failed to actually see the process of budding or fission, a fact which will surprise no one who has examined these extremely minute bodies, which are, as Beyerinck rightly puts it, among the smallest of living beings.

"The fact of infection, and the mode of infection, by means of a hypha-like filament passing down the root-hair were definitely established by myself in 1887, and it is satisfactory to find it confirmed in every essential detail by Prazmowski. Our views as to the symbiosis, the struggle between the protoplasm and the 'gemmules' (or 'bacteroids') are the same; though Prażmowski and Beyerinck carry the matter a step further in definitely inferring the absorption of the conquered bodies of the latter, a point in part supported by some of my experiments.

"As to the occurence, origin, and structure of the tubercles, Prażmowski's account is simply in accordance with my own; and it is interesting to note how many points of detail—the distortions of the root-hairs, the relations of the branching filaments to the nuclei and cell-contents, and those of the incipient tubercle to the end of the filament, for example—are confirmed by him."

Chemical Society, November 7.—Dr. W. J. Russell, F.R.S., President, in the chair.—The following papers were read:—Isolation of a tetrahydrate of sulphuric acid existing in solution, by Mr. S. U. Pickering. The freezing-points of mixtures of sulphuric acid and water form three distinct curves representing the crystallization of water, of the hydrate, $H_2SO_4 + H_2O$, and of sulphuric acid, and the highest point of each of these curves is in exact correspondence with the composition of the substance which crystallizes out. Solutions containing between 40 and 75 per cent. of sulphuric acid had not hitherto been frozen; but it appeared to the author that if his former deductions from the irregularities in the curves representing the densities and other properties of the solutions of the acid were correct, an independent curve representing the crystallization of a new hydrate should occupy this interval, and that this new hydrate should have the composition $H_2SO_4 + 5\frac{1}{2}H_2O$, or $H_2SO_4 + 4H_2O$. Experiment has proved it to be the latter. The two branches of the new curve rise from about $-80°$, and meet in a sharply marked angle at a point corresponding with the composition of the tetrahydrate, the temperature at which this point is reached being $-25°$. The tetrahydrate forms large, well-defined, hard crystals. The author regards the isolation of this hydrate as affording fresh confirmatory evidence of the hydrate theory of solution.—Additional observations on the magnetic rotation of nitric acid, and of hydrogen and ammonium chlorides, bromides, and iodides in solution, by Dr. W. H. Perkin, F.R.S. In his previous experiments, the author has limited his observations on nitric acid to the pure acid HNO_3; he has now examined a somewhat diluted acid, and the results indicate that HNO_3 unites with water, forming an acid analogous to orthophosphoric acid, viz. $(OH)_3NO$. The experiments on hydrogen chloride, bromide, and iodide were originally made on single samples in a very concentrated solution of each. These gave abnormally high results—rather more than twice the values calculated for the pure compounds—but on examination of solutions of different strengths, it was found that the rotation increases up to a dilution equivalent to about six or seven molecular proportions of water, to one molecular proportion of hydride, the value then remaining practically stationary. To see whether the solvent had any influence, a solution of hydrogen chloride in isoamyl oxide was examined, and was found to give values nearly identical with those calculated from the chlorine derivatives of the paraffins; and there can be little doubt that, if the other hydrides could be examined in a similar way, analogous results would be obtained. As union with water should reduce the rotations, the results are at present inexplicable. The compounds with ammonia and the compound ammonias have also been further examined; the results are remarkable when considered in relation to those afforded by the hydrides, as the rotations found, instead of being those calculated from the results obtained in the case of the paraffin derivatives, or those found in the case of hydrogen chloride dissolved in isoamyl oxide, nearly correspond with those required on the assumption that the hydrides are present in aqueous solution together with ammonia. The rotations, however, do not vary with the strength of the saline solutions. The author's explanation of this is that when the salts are dissolved in water, they dissociate almost entirely into the hydride and the amine, the hydride undergoing an increased rotation on account of its being in aqueous solution. In the case of triethylamine hydrochloride the numbers are lower, and there is evidently less dissociation; and in the case of tetrethylammonium chloride little or no dissociation appears to take place. Solutions of ammonium iodide and diethylamine hydrochloride in absolute alcohol gave somewhat lower numbers than aqueous solutions, indicating somewhat smaller, although still large, amount of dissociation. Ammonium nitrate and acid ammonium sulphate in aqueous solution give numbers agreeing closely with the calculated values, and apparently do not dissociate to any appreciable extent. In the discussion which followed the reading of this paper, Dr. Gladstone, F.R.S., stated that, on examining Dr. Perkin's solution of hydrogen chloride in isoamyl oxide, he found that the refraction and dispersion values deduced for the chloride are very much smaller than those afforded by aqueous solutions.—Phosphoryl trifluoride, by Prof. T. E. Thorpe, F.R.S., and Mr. F. J. Hambly. Phosphorus oxyfluoride, POF_3, may be easily and conveniently made by heating a mixture of cryolite and phosphoric oxide, and collecting the products at the mercurial trough.—Acetylation of cellulose, by Messrs. C. F. Cross and E. J. Bevan. On heating cotton cellulose with acetic anhydride and zinc chloride, a product is obtained which appears to be a pentacetyl derivative of cellulose. The compound is very stable, and on alkaline hydrolysis yields a substance having the properties of a normal cellulose. It would therefore appear that all the oxygen of the cellulose molecule acts as hydroxylic oxygen, and, in view of this result, a reconsideration of the present ideas as to the constitution of cellulose is rendered necessary.—Action of light on moist oxygen, by Dr. A. Richardson. The presence of liquid water very much facilitates the oxidation of many substances under the combined influence of sunlight and oxygen, but if the water is present as aqueous vapour, the decomposition is exceedingly slow, and in some cases is entirely arrested. The author finds that peroxide of hydrogen is formed when water containing pure ether, or pure water acidified with pure sulphuric acid, is exposed to light in an atmosphere of oxygen, and draws the conclusion that the oxidation of substances under the influence of light involves in many cases initially an oxidation of water to hydrogen peroxide, and that the oxidation of the compound is the result of a secondary interaction between it and the hydrogen peroxide. In the discussion which followed the reading of the paper, Prof. Armstrong pointed out that, whilst Dr. Richardson assumed that water was directly oxidized when mixed with ether and exposed to oxidation, Mr. Kingzett had argued—and in the case of turpentine had adduced weighty experimental evidence—that the hydrogen peroxide was a secondary product formed by the action of water on an organic peroxide. The use of ether or sulphuric acid, which Dr. Richardson had added with the object of protecting the peroxide, was to be deprecated, since hydrogen peroxide in weak solutions was comparatively stable; no satisfactory evidence had been adduced that the peroxide is formed in the absence of a third substance when water and oxygen are exposed to light. Prof. Dunstan remarked that he had found that hydrogen peroxide was not formed when pure ether was used, although a substance was obtained which was capable of liberating iodine from potassium iodide. The President said that in experiments which he and Captain Abney had made together on the fading of water-colours, the action of aqueous vapour had been most strikingly apparent; colours were found to be stable on exposure to light in dry air, which were considerably affected when aqueous vapour was present.—α-β-dibenzoylstyrolene and the constitution of Zinin's lepiden derivatives, by Prof. F. R. Japp, F.R.S., and Dr. F. Klingemann. The authors have continued their investigation of the interactions of dibenzoylstyrolene (anhydracetophenonebenzil), and find that there is an almost perfect parallelism in behaviour between it and one of the three isomeric oxy epidens prepared by Zinin, viz. the "acicular oxylepiden" melting at 220°. The various compounds obtained by them stand to the corre-

sponding compounds of the lepiden series in the relation of triphenyl derivatives of furfuran to tetraphenyl derivatives, a relation which is exhibited in the first place by dibenzoylstyrolene and oxylepiden themselves. Like "acicular oxylepiden," dibenzoylstyrolene yields two isomeric derivatives on heating; the isomeride formed in larger quantity in each case is almost certainly a derivative of crotolactone, whilst the isomeride formed in smaller quantity is probably a stereometric isomeride of "acicular lepiden" and dibenzoylstyrolene respectively.—Ethylic $\alpha\alpha_1$-diacetyladipate, by Prof. W. H. Perkin.—(1 : 2) methylethylpentamethylene, by Dr. T. R. Marshall and Prof. W. H. Perkin.—Action of reducing agents on α-ω-diacetylpentane; formation of (1 : 2) methylethylhexamethylene, by Dr. F. S. Kipping and Prof. W. H. Perkin.—Action of reducing agents on α-ω-diacetylpentane; formation of (1 : 2) dimethylheptamethylene, by the same.—Oxyamidosulphonates and their conversion into hyponitrites, by Dr. E. Divers, F.R.S., and Mr. T. Haga. The oxyamidosulphonates are the sulphazidates of Fremy, which Claus and Raschig have shown to be monosulphonic derivatives of hydroxylamine. The authors find that these compounds on treatment with alkali, instead of yielding hydroxylamine and the alkaline sulphate as asserted by Claus and Raschig, and as it is admitted they do when hydrolyzed by an acid, are converted exclusively into sulphite and hyponitrite, thus, $2HO . NH . SO_3K + 4KHO = (KON)_2 + 2K_2SO_3 + 4H_2O$. The reducing action of the oxyamidosulphonates has been examined, and it is found that the generally accepted view that it is due to the supposed conversion of these salts into sulphate and hydroxylamine, the latter then acting upon the copper hydroxide in the usual way, is untenable.—The alloys of lead, tin, zinc, and cadmium, by Mr. A. P. Laurie. In extension of his previous observations (Trans. Chem. Soc., 1888, 88), the author has made voltaic cells with the various alloys, and has thus compared their behaviour with that of the single metal by means of an electrometer. He concludes that the metals now examined do not combine together, thus confirming Matthiessen's conclusions.

November 21.—Dr. W. J. Russell, F.R.S., President, in the chair.—The following papers were read:—The law of the freezing-points of solutions, by Mr. S. U. Pickering.—The constituents of flax, by Messrs. C. F. Cross and E. J. Bevan. As a result of their examination of the cuticular constituents of the fibre, the authors have isolated ceryl alcohol, two fatty acids, of which one appears to be cerotic acid, an oily ketone, and a residue of complex, ill-defined, inert compounds yielding "ketones" on hydrolysis. These "ketones" have the characteristic odour of raw flax and flax goods, and from their property of emulsifying with water undoubtedly exercise an important influence on the wet processes of fine spinning of flax. The pectic group of constituents associated with the cellulose in the fibre proper is found to yield mucic acid on oxidation with dilute nitric acid, and flax cellulose when oxidized with potassium permanganate yields, in addition to oxycellulose and oxalic acid, acid substances from which furfural is obtained on acid hydrolysis.—Acetylcarbinol (acetol), by Prof. W. H. Perkin and Dr. J. B. Tingle. The authors announce the preparation of anhydrous acetylcarbinol.

Zoological Society, November 19.—Prof. W. H. Flower, F.R.S., President, in the chair.—The Secretary read a report on the additions that had been made to the Society's Menagerie during the month of October 1889, and called special attention to the arrival of a young male Gaur (*Bibos gaurus*) from Pahang, one of the native States in the Malay Peninsula, presented to the Society by Sir Cecil C. Smith, the Governor of the Straits Settlement.—The President exhibited and made remarks on a head of an African Rhinceros (*Rhinoceros bicornis*) with a third posterior horn partially developed. The animal from which it was taken had been shot by Sir John Willoughbey, in Eastern Africa.—The Secretary exhibited a skin of an albino variety of the Cape Mole-Rat (*Georychus capensis*), forwarded to the Society by the Rev. G. H. R. Fisk, of Cape Town.—Mr. A. Smith-Woodward exhibited and made remarks on a portion of the rostrum of an extinct Saw-fish (*Sclerorhynchus*) from the chalk of Mount Lebanon.—Mr. Goodwin exhibited and made remarks on specimens of some rare Paradise Birds obtained by him on Mount Owen Stanley, New Guinea, when in company with Sir William Macgregor's recent expedition; also some photographs taken on the same occasion.—A communication was read from the Rev. Thomas R. R. Stebbing and Mr. David Robertson containing the descriptions of four new British Amphipodous Crustaceans. These were named *Sophrosyne robertsoni*, *Syrrhoe fimbriata*, *Podoceropsis palmatus*, and *Podocerus cumbrensis*. Of these, *Sophrosyne robertsoni* belonged to a genus first observed at Kerguelen Island.—Mr. G. W. Butler read a paper on the subdivison of the body-cavity in Lizards, Crocodiles, and Birds, in which an attempt was made to analyze the complex conditions of the membranes observable in the last two groups, and to express them in terms of the simpler structures found in the Lizards.—Mr. J. H. Leech read the third part of his paper on the Lepidoptera of Japan and Corea, comprising an account of the *Noctuæ* and *Deltoidæ*; in all upwards of 475 species. Of these forty-six were now described as new to science, and two others were considered to be varietal forms.—Mr. R. Lydekker read a paper on the remains of a Theriodont Reptile from the Karoo System of the Orange Free State. The remains described were an associated series of vertebræ and limb-bones of a comparatively large Theriodont, which was probably different from any described form. The humerus was of the normal Theriodont type, and quite distinct from the one on which the genus *Propappus* had been fonnded, which the author considered to belong to a form closely allied to, if not generically identical with, *Pariasaurus*.—Mr. G. B. Sowerby read the descriptions of thirteen new or rare species of Land-Shells from various localities.—A communication was read from Mr. Edward A. Minchin containing an account of the mode of attachment of the embryos to the oral arms of *Aurelia aurita*. It was shown that the embryos of *Aurelia aurita* are developed on the arms, in broad capsules formed as evaginations of the walls of the oral groove, and that the capsules increase in size with the addition of more embryos.

Linnean Society, November 21.—Mr. W. Carruthers, F.R.S., President, in the chair.—Prof. Duncan exhibited and made remarks on a stem of *Hyalonema Sieboldii*, dredged between Aden and Bombay, a remarkable position, inasmuch as this Glass Sponge had not previously been met with in any waters west of the Indian Peninsula. Prof. Stewart criticized the occurrence, and referred to a parasite on the Sponge which had been found to be identical with one from the Japanese seas.—Mr. James Groves exhibited and gave some account of a new British Chara, *Nitella batrachiosperma*, which had been collected in the Island of Harris.—Mr. Thomas Christy exhibited some bark of *Quillaia saponaria* from Chili, which has the property of producing a great lather, and is extensively used for washing silk and wool. It is now found to solidify hydrocarbon oils and benzoline, and thereby to insure their safe transport on long voyages; a small infusion of citric acid rendering them again liquid.—Dr. F. Walker exhibited and made remarks on some plants collected by him in Ireland.—Mr. W. Hachett Jackson gave an abstract of an elaborate paper on the external anatomical characters distinctive of sex in the chrysalis, and on the development of the azygos evident in *Vanessa Io*.—Mr. E. B. Poulton followed by giving a *résumé* of his researches on the external morphology of the Lepidopterous pupa.—Mr. J. H. Leech gave an account of some new Lepidoptera from Central China.

PARIS.

Academy of Sciences, December 2.—M. Hermite in the chair.—On the fermentation of stable manure, by M. Th. Schlœsing. A series of experiments has been carried out by the author for the purpose of ascertaining whether, during fermentation under cover from the air, the manure of farmyards liberates nitrogen, as it is known to liberate a mixture of carbonic acid and methane. He finds that at the temperature of 52° C. no gaseous nitrogen is generated from the decomposition of nitric compounds; nor is any nitric combination formed by oxidation of ammonia in presence of organic substances. The organic matter loses more carbon than oxygen, the proportion of hydrogen remaining about the same. The reading of the paper was followed by some remarks by M. Berthelot on the same subject.—Remarks on the diastases secreted by *Bacillus heminecrobiophilus*, by M. Arloing. These researches show that under artificial cultivation this organism secretes several soluble ferments, enabling it to prepare for assimilation all the organic substances needed for the nutrition and development of a living being; and that amongst these ferments, or associated with them, there is one that transforms the organic matter, while liberating gases—that is, exercises a function hitherto attributed to the micro-organisms themselves, and not to their secretions.—Verbal report on the work of E. D. Suess, entitled "Das Antlitz der Erde," vols. i. and ii., 1885 and 1888, by M. Daubrée. This fundamental treatise on the constitution of the earth is here

described as a summary of the facts already established regarding the geology of the various parts of the globe, the essential features of its present mountain ranges and depressions, and the successive movements of the terrestrial crust of which these are the outcome. The work marks a new departure in the progress of physical geography.—Observations of Swift's new comet made with the Brunner equatorial at the Observatory of Toulouse, by M. B. Baillaud; and with the large equatorial at the Observatory of Bordeaux, by MM. G. Rayet and Picart. All these observations, extending from November 21 to November 27, give the same results: comet very faint and greatly diffused, making observations very difficult. Tables are also given of observations made at Algiers by MM. Trépied, Rambaud, Sy, and Renaux, during the same period.—Mechanical realization of thermodynamic phenomena, by M. Chaperon. Purely mechanical systems may be conceived, which present a striking analogy to heat-engines in respect of their influence on finite movements. The author here describes one of these systems, which is distinguished by its extreme simplicity.—On the correspondence between the characteristic equations of gases, by M. Ladislas Natanson. The author here shows that Wroblewski's posthumous memoir, published by the Vienna Academy in November 1888, forms a natural complement to Van der Waal's law that at absolute, that is, *corresponding* temperatures proportional to the critical temperatures of the different bodies, the pressures, P, of their saturated vapours are proportional to the respective critical pressures.—Method of measuring the spheric and chromatic aberrations of the objectives of the microscope, by M. C. J. A. Leroy. Finding in an artificial eye certain effects connected with the aberrations of sphericity and refrangibility, the author has applied the method known as "Cuignet's keratoscopy" to the study of the aberrations of the eye, and of the objectives of the microscope. His present observations are confined to the objectives alone.—On the electric conductivity of the Eiffel Tower and its conductors, by M. A. Terquem. It is shown that the tower with its complete system of lightning conductors, constructed under the direction of MM. Becquerel, Berger and Mascart, is calculated to afford perfect security for a considerable space round about.—Fresh researches on the preparation and density of fluorine, by M. Henri Moissan.—Papers were submitted by M. Daniel Berthelot, on the electric conductivities and multiple affinities of aspartic acid; by MM. E. Jungfleisch and L. Grimbert, on some facts relative to the analysis of sugars; by M. G Colin, on the varying effects of virulent substances used for inoculating animals; by M. P. Fliche, on the silicified woods of Algeria; by M. Stanislas Meunier, on the Phu-Hong meteorite, with remarks on the limerick type; and by M. Léon Teisserenc de Bort, on the distribution of atmospheric pressure over the surface of the globe.

DIARY OF SOCIETIES.

LONDON.

THURSDAY, DECEMBER 12.

ROYAL SOCIETY, at 4.30.—The Relation of Physiological Action to Atomic Weight: Miss H. J. Johnstone and Prof. T. Carnelley.—An Experimental Investigation into the Arrangement of the Excitable Fibres of the Internal Capsule of the Bonnet Monkey (Macacus sinicus): Dr. Beevor and Prof. V. Horsley, F.R.S.—On the Effect of the Spectrum on the Haloid Salts of Silver: Capt. Abney, F.R.S., and G. S. Edwards.—Magnetic Properties of Alloys of Nickel and Iron: Dr. Hopkinson, F.R.S.

MATHEMATICAL SOCIETY, at 8.—On the Radial Vibrations of a Cylindrical Shell: A. B. Basset, F.R.S.—Note on 51840-Group: G. G. Morrice.—On the Flexure of an Elastic Plate: Prof. H. Lamb, F.R.S.—Notes on a Plane Cubic and a Conic: R. A. Roberts.—Complex Multiplication Moduli of Elliptic Functions for the Determinants − 53 and − 61: Prof. G. B. Mathews.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Annual General Meeting.—Election of Council and Officers for 1890.—Electrical Engineering in America: G. L. Addenbrooke. (Discussion.)

FRIDAY, DECEMBER 13.

ROYAL ASTRONOMICAL SOCIETY, at 8.

QUEKETT MICROSCOPICAL CLUB, at 8.

INSTITUTION OF CIVIL ENGINEERS, at 7.30.—Hydraulic Station and Machinery of the North London Railway, Poplar: John Hale.

SATURDAY, DECEMBER 14.

ROYAL BOTANIC SOCIETY, at 3.45.

SUNDAY, DECEMBER 15.

SUNDAY LECTURE SOCIETY, at 4.—The Geology of London (with Oxy-hydrogen Lantern Illustrations): Rev. J. F. Blake.

MONDAY, DECEMBER 16.

SOCIETY OF ARTS, at 8.—Modern Developments of Bread-making: William Jago.

ARISTOTELIAN SOCIETY, at 8.—Symposium—Is there Evidence of Design in Nature?: S. Alexander, Dr. Gildea, Miss Naden, G. J. Romanes.

TUESDAY, DECEMBER 17.

ROYAL STATISTICAL SOCIETY, at 7.45.—Accumulations of Capital in the United Kingdom in 1875-85 (with reference to a Paper read in 1878): Dr. Robert Giffen.

INSTITUTION OF CIVIL ENGINEERS, at 8.—On the Triple-Expansion Engines and Engine Trials at the Whitworth Engineering Laboratory, Owens College, Manchester: Prof. Osborne Reynolds, F.R.S. (Discussion.)

UNIVERSITY COLLEGE BIOLOGICAL SOCIETY, at 5.15.—Amphioxus: C. E. Franck.

WEDNESDAY, DECEMBER 18.

SOCIETY OF ARTS, at 8.—London Sewage: Sir Robert Rawlinson, K.C.B.

GEOLOGICAL SOCIETY, at 8.—On the Occurrence of the Genus Girvanella, and Remarks on Oolitic Structure: E. Wethered.—On the Position of the Westleton Beds or "Pebbly Sands" of Suffolk to those of Norfolk, and on their Extension Inland, with some Observations on the Period of the Final Elevation and Denudation of the Weald and of the Thames Valley, Part 2: Prof. Joseph Prestwich, F.R.S.

ROYAL METEOROLOGICAL SOCIETY, at 7.—Report of the Wind Force Committee on the Factor of the Kew Pattern Robinson Anemometer: drawn up by W. H. Dines.—On Testing Anemometers: W. H. Dines.—On the Rainfall of the Riviera: G. J. Symons, F.R.S.—Report on the Phenological Observations for 1889: Edward Mawley.

UNIVERSITY COLLEGE CHEMICAL AND PHYSICAL SOCIETY, at 4.30.—The Magnetization of Iron and Nickel: J. J. Stewart.

THURSDAY, DECEMBER 19.

ROYAL SOCIETY, at 4.30.

LINNEAN SOCIETY, at 8.—Intensive Segregation and Divergent Evolution in Land Mollusca of Oahu: Rev. John T. Gulick.—Dictopteris; with Remarks on the Systematic Position of the Dictyotaceæ: T. Johnson.

CHEMICAL SOCIETY, at 8.—On Frangulin: Prof. Thorpe, F.R.S., and H. H. Robinson.

ZOOLOGICAL SOCIETY, at 4.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Australia Twice Traversed, 2 vols: E. Giles (Low).—Physiology of Bodily Exercise: Dr. E. Lagrange (Kegan Paul).—Linear Differential Equations, vol. i.: Dr. T. Craig (Trübner).—Philosophy of the Steam-Engine: R. H. Thurston (Trübner).—The British Journal Photographic Almanac, 1890 (Greenwood).—Absolute Measurements in Electricity and Magnetism, 2nd edition: A. Gray (Macmillan).—Occasional Thoughts of an Astronomer on Nature and Revelation: Rev. Dr. Pritchard (Murray).—Star-Land: Sir R. S. Ball (Cassell).—The Story of Chemistry: H. W. Picton (Isbister).—A Text-book of Assaying: C. Beringer and J. J. Beringer (Griffin).—History and Pathology of Vaccination, 2 vols.: Prof. E. M. Crookshank (Lewis).

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